POWER PLANT ENGINEERING

Established Over 31 Years

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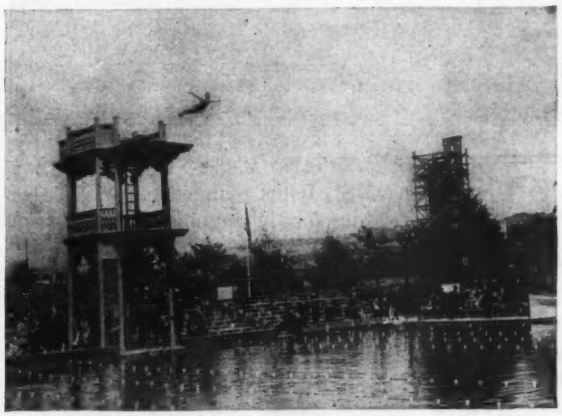


Yoo-hoo! Skin-nay! C'mon In!

OF COURSE I looked around, though I am neither skinny nor did I know the small boys in the town, but out of the habits of my own youth, I knew the boys were getting up a swimming party, although it was too cold, I thought, to enjoy an outdoor swim. With my curiosity thus aroused, I hailed the leader:

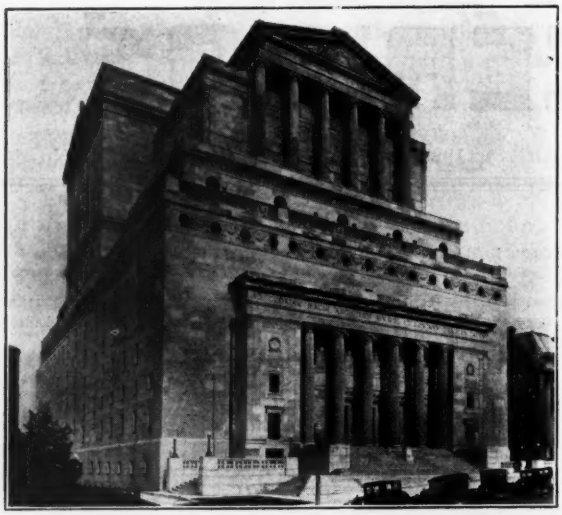
"What's the idea on a day like this?"

"You're all wet, big boy. Come on over an' we'll show you some stunts."

Well, they did. Leave it to the kids. An old shed for a bath house and the power house spray pond for a swimming pool. Fine idea. Who but kids would ever think of it?

Develop that idea into the picture above and you have, with very little additional expense, a bathing beach that can be used from real early spring until the snow flies in the fall. This is just one of those varied services which a public utility can perform in its community where outdoor water is scarce.

Then too, with a little dolling up, the spray pond can be made a very pretty spot in the surroundings of the plant. Other methods of attracting attention to power plants by a touch of Nature's art are mentioned in the article on page 1039 of this issue. As an additional drawing card, we suggest that the engineer learn to do the swan dive like this bird—This way for your tickets to the big show!



Masonic Temple in St. Louis Generates Own Power

DECISION TO INCLUDE A POWER PLANT IN THE MAIN BUILDING WAS MADE AFTER STEEL STRUCTURE AND CONCRETE SLABS AND FIREPROOFING WERE IN PLACE MAKING IT NECESSARY TO INSTALL THE EQUIPMENT IN LIMITED QUARTERS. BY GEO. E. WELLS AND JOS. A. OSBORN*

ORIGINALLY THE MASONIC Temple Association of St. Louis planned to erect a separate building for the engine and boiler rooms but this plan was later abandoned and decision made to include the power plant in the main building. This final decision came after the steel skeleton structure and concrete slabs and fireproofing were in place. Naturally as few changes as possible in the structure were desired and, as none of the committee was anxious to give up any of their allotted space, the problem was difficult. It has, however, been solved satisfactorily and although floor space and cubical content per horsepower are at a minimum, the mechanism is all readily accessible to the operator and there is ample space for repair work on the machinery when necessary.

Figures in the table show that but 5.338 sq. ft. and 60.899 cu. ft. per installed kilowatt has been allowed for boilers, engines and auxiliaries. It is believed that there are few other plants of the same size which can boast of figures as low as these. To some engineers the matter of space per horsepower may be a new thought, but it is one which should be given consideration in all designs. Waste space in a plant increases expenses and decreases the net profits just that much.

In the present case latitude ordinarily permissible in working out plans for a plant of this size was not allowed because the building structure was already in place. With more freedom of arrangement it might be possible to reduce the unit space below the figures given, although it is believed that they are close to the minimum. Detailed drawings of all pipe lines were made and just sufficient space allowed for valves, fittings, pipe covering and space to permit the handling of wrenches and tools. After this layout had been checked, first in the drafting room and then on the job with the various erection foremen, a completed layout was made and the steam fitters, plumbers, electricians, boiler makers, tinsmiths, brick masons, carpenters and concrete workers were not allowed to deviate from them, as a deviation by anyone would have interfered with all of the others.

SPACE AND VOLUME PER UNIT OF POWER ARE LOW

	Total sq ft.	Sq. ft. per b.hp.	Sq.ft. per kw.
Floor space			
Boiler room	1312	.875	1.312
Auxiliaries	1518	1.012	1.518
Boiler room total	2830	1.887	2.830
Engine room	2508	1.672	2.508
Total	5338	3.559	5.338
	Total cu. ft.	Cu. ft. per b.hp.	Cu. ft. per kw.
Volume			
Boiler room	29,997	19.999	29.997
Auxiliaries	5822	3.881	5.822
Boiler room total	35,819	23.880	35.819
Engine room	25,080	16.72	25.080
Total	60,899	40.60	60.899

There are two 300-hp. boilers and one 150-hp. boiler, or a total of 750 hp. The engine room contains two 400-kw. and one 200-kw. units, or a total of 1000 kw. All electric current for lighting the building, operating the motors, including the elevators, is generated in the building. In winter the exhaust steam is utilized for heating the building and for feed-water heating. The main exhaust line from the engine room to the feed-water heater is 20 in. in diameter; from there it is continued with a 16-in. pipe through a pipe tunnel and up the main pipe shaft to the highest roof level in the building.

*Associated Consulting Engineers for the Masonic Temple Assn.

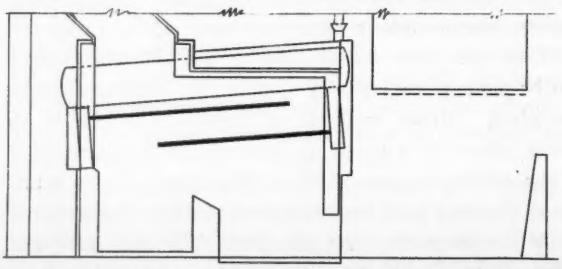


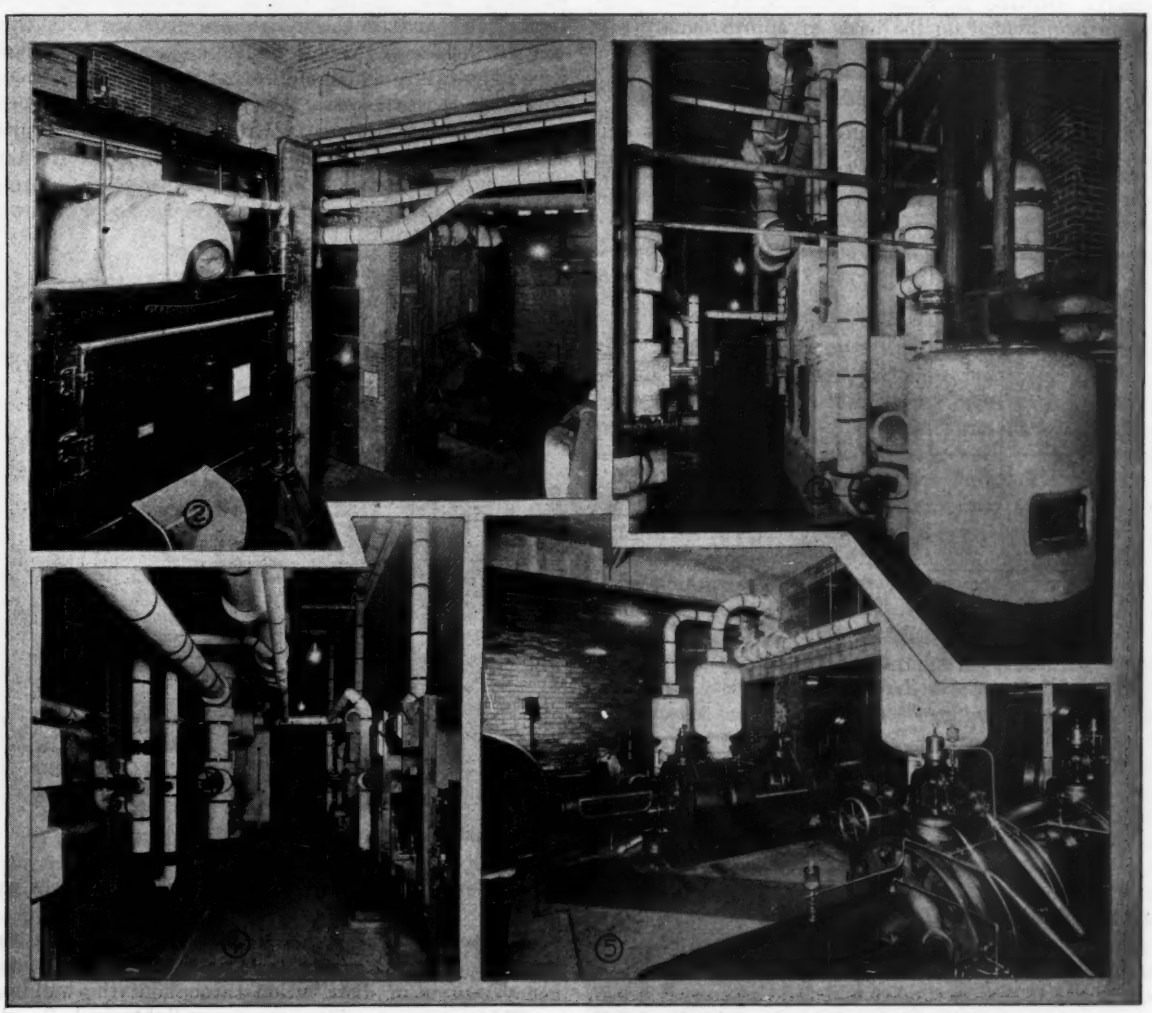
FIG. 1. HORIZONTAL TILE BAFFLES ARE USED IN THE BOILER

Branches are taken off in various floors to supply the different heating units and for direct radiation.

Cork Used to Isolate Engine Foundations

Due to the necessity of avoiding all noises in the building, incident to engine vibration or also due to all foundation resting on solid rock, 3.in. of cork insulation has been provided. This cork completely lines the excavation and encases all columns, footings, and so forth, so that machinery foundations can not come in contact with any part of the building footing.

Condensate from the entire heating system and all steam lines is returned to the feed-water heater so that no hot water is wasted in any part of the system. The feed-water heater is of a three-unit type using exhaust steam from the auxiliaries and as much of the exhaust from the engine as is necessary. Steam at 150 lb. is supplied to the engine room through a 12-in. header. Boiler settings are made wholly of fire brick, entirely encased with No. 8 sheet steel casings held in place by steel anchors. The casings are grouted into grooves in the foundation, making the fittings as air tight as possible. A layer of 2-in. insulation is placed between the firebrick setting and the steel casing. Horizontal tile baffles are used in the boilers which are fired by underfeed stokers. The stokers and forced draft fans are driven by a single steam engine through a line shaft. The stack, located in a shaft inside the building, is 94 in. in diameter and extends 183 ft. above the boiler room floor. The stack is entirely self-supporting with an air space left around it to prevent heat being transmitted into rooms adjoining the shaft. A steel breeching connecting all boilers to the stack is located on the mezzanine floor above the boiler room and is well insulated with asbestos covering.



FIGS. 2-5. VIEWS OF VARIOUS PARTS OF THE POWER PLANT

A black slate switchboard is installed in one corner of the engine room. One control panel is provided for each generator and its exciter, one panel for the substation control, two panels for three- phase, 440-v. power distribution and three panels for single-phase, 115 to 230-v. lighting control. All power and light circuits are provided with renewable fuses mounted on separate panels to the rear of the switchboard.

In the small substation enclosure located in the engine room are three 150-kv.a., one 75 and one 25-kv.a. transformers. The three 150-kv.a. transformers are used

to reduce the 460-v., three-phase current to 115 and 230 v. for the lighting circuit, the 75-kv.a., three-phase, 4000-v. transformer is used to reduce the outside 4000-v. service to 460 v., three phase for emergency power use, while the 25-kv.a., 4000-v. transformer is used to reduce the 4000-v. outside service to 115, 230 v. for emergency lighting use. Normally the emergency lighting feeders are connected to the main switchboard, but in case of failure in the power plant, this feeder is automatically transferred to the 225-kv.a. outside service line. The 75-kv.a. outside service transformer is used only for power during periods of shutdown or on Sunday. Outside purchased power in the above connection is provided on the basis of approximately $75 per month minimum charge.

Unusual Features Included in Wiring System

As installed in this building the electric light and power distribution system is of particular interest and incorporates several features not commonly found in similar installations. In designing this system, 450-v., 3-phase current was selected as being the most economical for all power distribution. One leg of the three power system was grounded and the power switches in the switchboard, as well as to all branch circuits in the tablet board, are provided with fuses only in the two legs, the third or grounded leg being carried through solid. Figure 10 indicates the scheme of connections used. Light is distributed on 115 and 230-v., 3-wire feeders and, to comply with safety rules it is, of course, necessary to ground the neutral wires. This grounding would not have been possible with the usual three-phase secondary distribution so, in order to provide a perfect balance and at the same time ground all neutral wires, the three main line switchboard panels are fed from a bank of transformers as follows:

Three 150-kv.a., single-phase transformers are used. The 460-v. or primary windings are connected in delta to the three-phase bus bars of the switchboard. The 115 and 230-v. secondary windings of each transformer feed a separate, single-phase, 115 and 230-v. lighting panel in the switchboard. The neutral of each single-phase winding of the transformers was grounded. Thus there are six 230-v. wires and one neutral or common return wire between the transformer station and the three switchboard panels.

It will be noted that the three-wire feeders to centers of distribution throughout the building are controlled by a double pole knife switch having fuses in two legs only. The neutral is connected solid throughout the building. All lighting branch circuits running from the tablet boards to the outlets are provided with only one fuse and a single pole tumble switch. One marked wire is used throughout indicating neutral or grounded wire. As it was necessary to provide a separate emergency light installation throughout the building which could be fed from an outside source of supply, in case of an accident to the plant, the following method was employed.

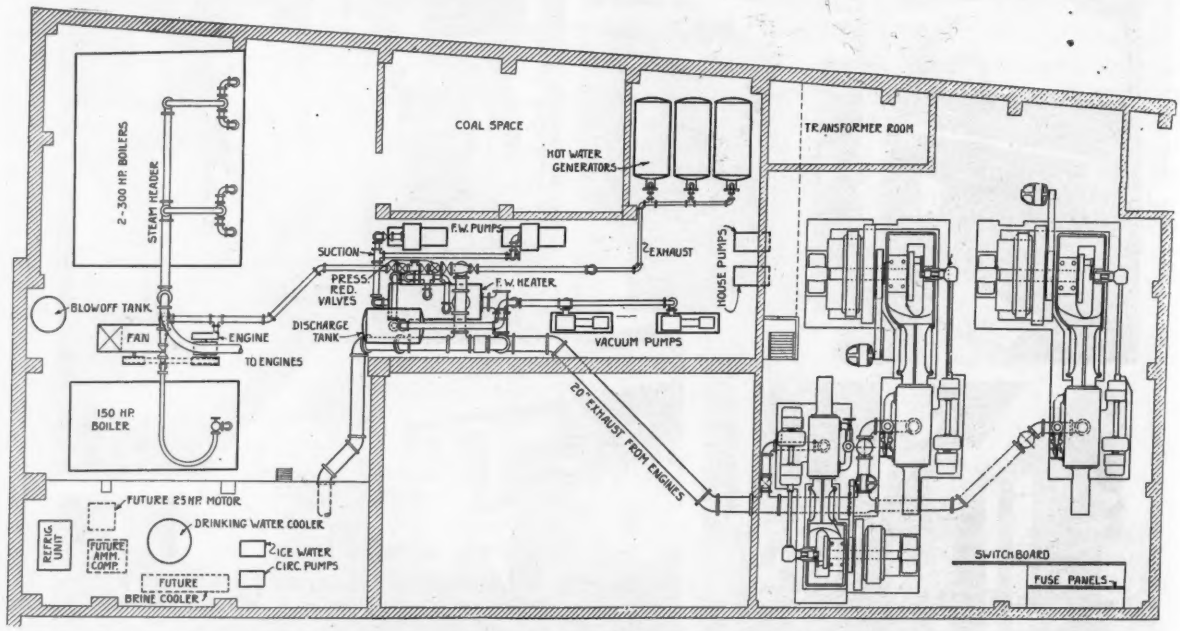


FIG. 6. ENGINES ARE INSTALLED ON THE LEVEL ABOVE THE BOILER ROOM FLOOR

An entire separate emergency lighting system was installed comprising a feeder which fed separate emergency centers of distribution throughout the building.

This service provides emergency lights in halls, elevators, exits and fire escapes. The emergency feeder is controlled by knife switch "E" on the switchboard which is not directly connected to the bus bars but is provided with two independent sources of supply. Each source being fed through a solenoid contactor—one contactor being connected to the switchboard bus bars and the other connected to the 25-kv.a. single-phase transformer, which in turn is fed from the 4000-v. outside service of the power company.

Operating solenoids of the contactors have interlocked connections and operate as follows: When the switchboard bus bars are energized, the contactor on panel 8 is closed, thus feeding switch "E" from the

switchboard bus bars. In the event of the bus bar being de-energized, the contactor on panel 8 opens and in so doing automatically connects the solenoid control circuit of the contactor on panel 9 across the single-phase outside source of supply, thus connecting feeder switch "E" with the outside source and providing the necessary emergency lighting throughout the building. When the bus bars again become energized the contactor on panel 8 closes. This automatically opens the operating circuit of the contactor on panel 9. This disconnects the outside source of supply to switch "E" and reestablishes normal connections to the switchboard. The contactors function so quickly that no interruption is noticed in the emergency lighting during the change. The secondaries of the 75-kv.a. transformer, which are fed from the outside source of supply for the purpose of supplying a limited quantity of power for elevators, etc., on Sundays and during the night after the main plant is shut down, are, of course, connected to the main bus bars which furnishes the necessary light and power to any part of the building up to 75 kw.

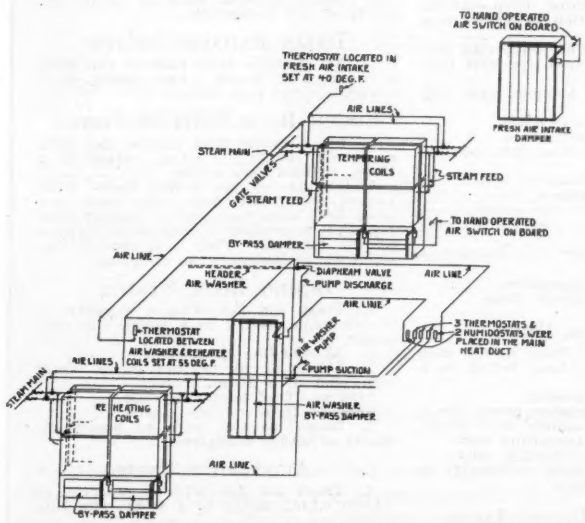


FIG. 7. ARRANGEMENT OF A TYPICAL HEATING UNIT

Six passenger and one freight elevators are installed in the building, the passenger elevators being the latest type drive with full magnet control. Each elevator is provided with a motor generator set operated from a three-phase alternating current feeder to supply the direct current for control and operation of the elevators. This system of drive not only provides even and noiseless operation but eliminates all fluctuation of voltage on the electric system.

There are three systems of lighting throughout the building, namely, direct, semi-direct and indirect. In the lodge rooms the light comes through the ceiling recess units supplied with suitable art glass. Each lodge room is provided with a dimmer unit so that illumination can be maintained at any intensity from dark to maximum brightness. Lighting in the commandery hall is indirect, three color effect, the ceiling being provided with 20,000 watts each of red, blue and white lights. By means of suitable dimmers any combination of colors desired can be obtained. Stage lighting in chapter, council and auditorium is provided for

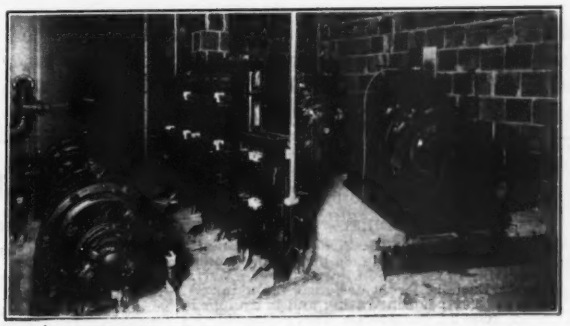


FIG. 8. EACH ELEVATOR IS SERVED BY A MOTOR GENERATOR SET

with the usual foot, border and spotlights, wired for three colors. Each unit is provided with a control switchboard so that any desired effect can be obtained with the lighting equipment. The exterior of the building is provided with flood lighting units equipped with 1000-watt projectors. These flood light units are so placed that they eliminate shadows. The total capacity used will be 60 kw.

Many of the Rooms Have No Windows

Ventilation was extremely important, as the greater part of the building, such as lodge rooms, commandery, chapter and council rooms, dining room with a seating capacity of 3000, and the auditorium with a seating capacity of 2500 have no exterior walls. One heating and ventilating plant in the entire building would have necessitated vents of unwieldy size and as the various portions are used at different times, separate heating plants were designed for different parts of the building. These plants function independently of each other except that they all receive steam from the main 16-in. exhaust line. Ten of these units in various parts of the building take care of the following: Dining room, auditorium, social room, second, third and fourth floor lodge rooms, commandery and chapter, council, toilet, exhaust, and engine and boiler room exhaust.

Fresh air is taken into the building from the outside through a damper controlled by an air switch. This air then passes through two sets of the preheating or tempering coils. Steam through the first group is controlled by thermostats placed just inside the fresh

FIG. 9. NINE PANELS TAKE CARE OF THE ELECTRICAL DISTRIBUTION

air damper, while steam through the second set is controlled by a thermostat located between the air washer and the preheating coils. Air is heated to approximately 65 deg. F. in passing through these two sets of coils, after which it enters the air washer, passing through a very fine spray of water which removes all dust and dirt. A certain amount of moisture is absorbed in passing through the washer. The amount absorbed is a function of the spray nozzle pressure. The higher the pressure, the finer the spray and the higher the moisture content of the air. A humidistat placed in the main duct which conveys the washed and heated air to the various rooms, controls this pressure through a diaphragm valve on the circulating water line.

Principal Mechanical Equipment in the St. Louis Masonic Temple

Boilers

2. Heine Boiler Co. 3060-sq. ft. straight tube boilers with two 36-in. diam. drums and 171 tubes 3.5 in. diam. and 18 ft. long. Each boiler is designed for a maximum of 200 per cent rating and is equipped with two 2.5-in. Ashton Valve Co. safety valves, 1 D. T. Williams Valve Co. water column and feed-water regulator with high and low water alarms, Bayers Co. soot blowers and Lunkenheimer Co. stop and check valves.

1. Heine Boiler Co. 1620-sq. ft. straight tube boiler with one 42-in. drum and 84 tubes 3.5 in. diam. and 18 ft. long. This boiler is also designed for a maximum rating of 200 per cent and is equipped with the same appurtenances.

Stokers

3. Detroit Stoker Co. underfeed stokers with side ash dumps and mechanically operated rams.

1. Troy Engine & Machine Co. 7 by 7-in. vertical steam engine belted to a line shaft for driving the stokers and a Clarage Fan Co. No. 90 forced draft fan with a 66-in. diam. wheel and a capacity of 30,000 c.f.m. against a 5-in. static head.

Boiler Auxiliaries

2. American Steam Pump Co. 10 by 6 by 10 duplex outside end packed, pop valve, plunger type boiler feed pumps, bronze fitted and equipped with Hills-McCanna Co. force feed oil lubricators and Kieley & Mueller governors.

1. Swartwout Co. Type A3 42-in. feed-water heater with 56 cu. ft. of steam space, 84 cu. ft. water capacity and 24 sq. ft. of filter area.

2. Cochrane Corp. 16-in. multiport safety exhaust back pressure inlet valve on each end of the 16-in. exhaust steam line.

2. American Steam Pump Co. 10 by 14 by 12 in. vacuum pumps, bronze fitted and equipped with Hills-McCanna Co. force feed lubricators and Kieley & Mueller governors.

3. Sims Co. No. 12 48 by 96-in. hot water heaters with ½-in. copper steam coils. Condensate returns to vacuum system by 1¼-in. Bundy Steam Trap Co. traps.

2. Dayton Valve & Pump Co. 250-g.p.m. centrifugal house pumps direct connected to 20-hp. General Electric motors. These pumps pump water to two 11-ft. diam., 10-ft. high storage tanks on the top floor of the building.

1. York Co. vertical single-acting, self-contained 3 by 3-in. ammonia compressor driven by a 7.5-hp. motor with full automatic control.

2. Chippewa Pump Co. 1¼-in. centrifugal ice water pumps direct connected to 5-hp. General Electric motors. Water cooled in a cooler 5 ft. in diam., 6 ft. 6 in. high, of the open crank type with 1¼-in. coils.

Engines and Generators

2. Hooven, Owens, Rentschler Co. 26 by 36 Hamilton uniflow engines direct connected to Westinghouse 150-r.p.m., 3-phase, 440-v., 60-cycle, 40-deg., 400-kw. generators. Each engine with a 22.5-kw., 150-v. belted exciter.

1. Hooven, Owens, Rentschler Co. 20 by 24-in. Hamilton uniflow engine direct connected to Westinghouse 200-r.p.m., 3-phase, 440-v., 60-cycle, 40-deg., 200-kw. generator with a 15-kw., 150-v. belted exciter.

3. Maloney Electric Co. 150-kv.a., 40-deg., 460 to 115 and 230-v. single-phase transformers.

1. Maloney Electric Co. 75-kv.a., 40-deg., 4000 to 460-v., 3-phase transformer.

1. Maloney Electric Co. 25-kv.a., 40-deg., 4000 to 115 and 230-v. single-phase transformer.

Heating and Ventilating Equipment

American Blower Co.—fans for the heating and ventilating system.

Johnson Heat Regulating Co.—automatic temperature regulating apparatus including thermostats, humidostats, air switches, diaphragm valves, Sylphon bellows, radiator valves and Louvre dampers. This equipment also includes a two-pipe air system and 4 by 4-in. double cylinder air compressor direct connected to a ¾-hp. motor complete with an 18 in. by 5-ft. air receiver.

Buffalo Forge Co.—air washers.

Dayton Valve Co.—air washer water circulating pumps.

Wagner Electric Co.—440-v., 3-phase, 60-cycle motors for fans and pumps.

Cutler-Hammer Mfg. Co.—motor control equipment.

Air Conditioning & Engineering Co.—ozone machines.

United States Radiator Corp.—18,321 sq. ft. of direct radiation in Triton pipe radiators.

American Radiator Co.—tempering and reheating coils of the Vento type with cast-iron sections.

Sarco Co.—radiator vacuum and drip traps.

Reading Co.—wrought iron pipe.

National Tube Co.—steel pipes.

Walworth Co. and Crane Co.—cast-iron pipe fittings.

Fairbanks Co.—hand control valves.

Durabla Mfg. Co.—gaskets.

Johns-Manville Corp.—pipe covering.

Kieley & Mueller Co.—pressure reducing valves.

Stevens Soundproofing Co.—soundproof machinery foundations.

Cochrane Corp.—oil separators.

V. D. Anderson Co.—steam traps.

Social Room Units

1. No. 7 single inlet fresh air fan with a capacity of 16,000 c.f.m., belted to a 10-hp. slip ring motor.
1. 16,000-c.f.m. air washer.
1. 200-g.p.m. air washer pump direct connected to a 7.5-hp. squirrel cage motor.
324 sq. ft. of Vento tempering coils.
324 sq. ft. of Vento reheating coils.
1. Ozone machine with an hourly capacity of 1590 milligrams.

Second Story Units—Lodge Room

1. No. 9 double inlet fresh air fan with a capacity of 55,000 c.f.m., belted to a 30-hp. slip ring motor.
1. 55,000-c.f.m. air washer.
1. 400-g.p.m. air washer pump direct connected to a 15-hp. squirrel cage motor.
756 sq. ft. of Vento tempering coils.
1064 sq. ft. of Vento reheating coils.
1. Ozone machine with an hourly capacity of 3180 milligrams.
1. No. 6 single inlet exhaust fan with a capacity of 10,000 c.f.m., belted to a 3-hp. squirrel cage motor.

Third Story Units—Lodge Room

1. No. 10 double inlet fresh air fan with a capacity of 65,000 c.f.m., belted to a 40-hp. slip ring motor.
1. 65,000-c.f.m. air washer.
1. 500-g.p.m. air washer pump direct connected to a 15-hp. squirrel cage motor.
912 sq. ft. of Vento tempering coils.
1368 sq. ft. of Vento reheating coils.
1. Ozone machine with an hourly capacity of 3180 milligrams.
1. No. 8 single inlet exhaust fan with a capacity of 20,000 c.f.m., belted to a 7.5-hp. squirrel cage motor.

Commandery Units

1. No. 9 double inlet fresh air fan with a capacity of 50,000 c.f.m., belted to a 50-hp. slip ring motor.
1. 50,000-c.f.m. air washer.
1. 400-g.p.m. air washer pump direct connected to a 15-hp. squirrel cage motor.
1064 sq. ft. of Vento tempering coils.
1368 sq. ft. of Vento reheating coils.
1. Ozone machine with an hourly capacity of 4470 milligrams.

Chapter and Council Units

1. No. 6 double inlet fresh air fan with a capacity of 22,000 c.f.m. belted to a 15-hp. slip ring motor.
1. 22,000-c.f.m. air washer.
1. 200-g.p.m. air washer pump direct connected to a 7.5-hp. squirrel cage motor.
494 sq. ft. of Vento tempering coils.
741 sq. ft. of Vento reheating coils.
1. Ozone machine with an hourly capacity of 795 milligrams.

Toilet Exhaust System

1. No. 7 single inlet exhaust fan with a capacity of 15,000 c.f.m., belted to a 7.5-hp. squirrel cage motor.

Engine Room Exhaust System

1. No. 6 double inlet exhaust fan with a capacity of 20,000 c.f.m., belted to a 15-hp. squirrel cage motor.

Installation of the dining room, auditorium and fourth floor lodge room systems have been temporarily delayed until funds are subscribed to finish these portions of the building. They will contain the following equipment when completed:

Dining Room System

1. Fresh air fan with a capacity of 93,000 c.f.m., belted to a 50-hp. slip ring motor.
1. 93,000-c.f.m. air washer.
1. 750-g.p.m. air washer pump direct connected to a 20-hp. motor.
1296 sq. ft. of tempering coils.
1652 sq. ft. of reheating coils.
1. Ozone machine with an hourly capacity of 93,000 milligrams.

Auditorium Units

1. Fresh air fan with a capacity of 64,000 c.f.m., belted to a 40-hp. slip ring motor.
1. 64,000-c.f.m. air washer.
1. 450-g.p.m. air washer pump driven by a direct connected 15-hp. motor.
1134 sq. ft. of tempering coils.
1216 sq. ft. of reheating coils.
1. Ozone machine with an hourly capacity of 6400 milligrams.
1. Exhaust fan with a capacity of 40,000 c.f.m., belted to a 20-hp. motor.

Kitchen Exhaust System

1. Exhaust fan with a capacity of 40,000 c.f.m., belted to a 20-hp. exhaust fan motor. This system will also serve the dining room exhaust.

Fourth Floor Units—Lodge Room

1. Fresh air fan with a capacity of 65,000 c.f.m., belted to a 40-hp. motor.
1. 65,000-c.f.m. air washer.
1. 500-g.p.m. air washer pump driven by a 50-hp. direct connected motor.
912 sq. ft. of tempering coils.
1064 sq. ft. of reheating coils.
1. Ozone machine with an hourly capacity of 3180 milligrams.
1. Exhaust fan with a capacity of 14,000 c.f.m., driven by 7.5-hp. motor.

This humidistat is acted upon by the moisture in the air in much the same manner as the thermostat is acted upon by temperature. In the event that the moisture content of the air becomes so great that it exceeds the range of the humidistat controlling the water valve, a second humidistat automatically opens a bypass damper operated by an air switch, bypassing a certain portion of the air around the air heater. This damper remains open until the moisture content of the air again becomes normal or within the range of the first instrument.

After leaving the air washer the air passes through two sets of reheating coils where its temperature is raised to approximately 100 deg. F. The steam supplied to these reheating coils is controlled by diaphragm valves automatically operated by thermostats placed in the main duct. In this system a certain amount of air is re-circulated, as will be described more in detail later. There is some likelihood of the air temperature in the main duct exceeding the range of the two thermostats previously mentioned. This condition is provided for by placing a damper to bypass a certain portion of the air around the reheating coils. This reheating coil bypass damper is operated by an air switch automatically controlled by a thermostat placed in the main duct alongside of the other thermostat.

From the reheating coils the air enters a motor-driven fan which discharges it to the main duct, forcing it through the various branches, through the air registers and into the various rooms to be heated and ventilated. A set of exhaust or vent registers are also located in these rooms and are connected by ducts to another fan which exhausts the used air. This exhaust fan discharges the air to the outside.

Recirculated Air Reduces Heating Costs

Recirculated air, as previously mentioned, forms an important part of the ventilating system. It is obvious that the air leaving the rooms through the vent registers is still warm and, in order to conserve this heat, a certain percentage of the air is returned from the rooms to the heating system, a separate set of exhaust registers and ducts being installed for this purpose. These ducts convey the recirculated air back to a point between the tempering coils and the air washer. In severe winter weather, approximately 75 per cent of the air leaving the rooms is returned to the heating system and 25 per cent is discharged to atmosphere by the exhaust fan.

To guard against this recirculated air becoming stale or foul, an electric ozone machine is installed in each recirculating system. This ozone machine discharges a spray of ozone into the air as it enters the main fan. This ozone spray is an electrical production and in the past there has been some controversy concerning its use. Some engineers have also opposed the recirculation of any part of the air. At the present time recirculation and the use of ozone have reached the stage where a great majority of engineers and physicians agree that the practice of recirculating a large portion of the air is entirely justified and has no ill effects upon the occupants of the building. In fact, some claim that the ozone is a cure for colds. Regardless of the hygienic controversy, however, there is no argument regarding the saving of coal when heating in this manner.

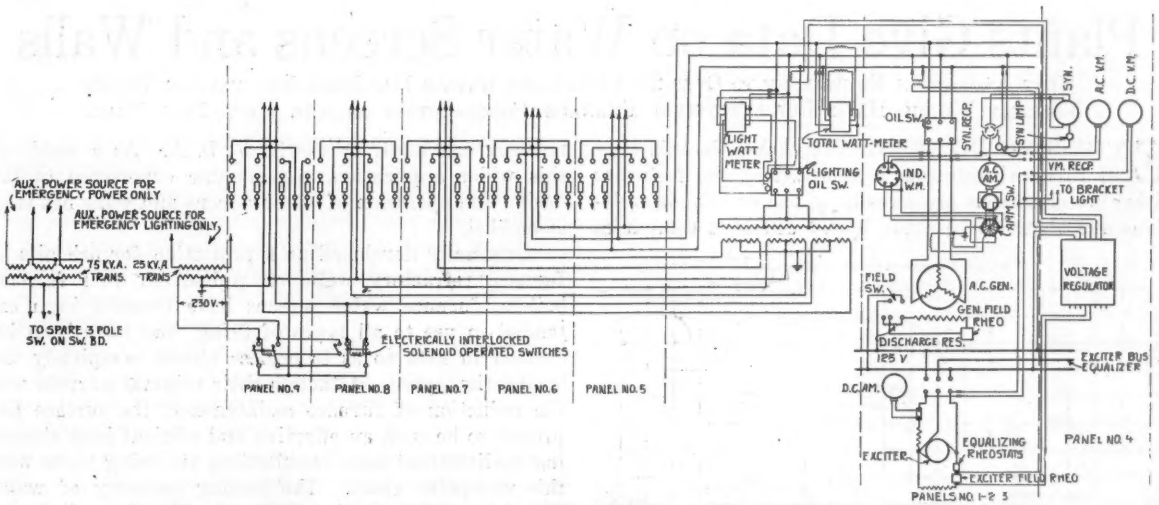


FIG. 10. SEVERAL NOVEL FEATURES ARE INCORPORATED IN THE DISTRIBUTION WIRING SYSTEM

Variable speed fan motors are used in order to vary the quantity of air circulated which is 2 or 3 times as great in summer as in winter. Air washer sprays are also operated at greater pressures in summer than in winter to take care of the greater volume of air passing through them. In summer the circuit of the air is much the same as in winter, except that no air is recirculated and naturally no steam is used. The ozone machine will operate at full capacity in summer and play an important part in making air conditions agreeable. Originally the intention was to refrigerate the air in summer but on account of the original cost and the cost of operation, this system was not installed. Provision was made for it, however, and it can be put in at any time desired.

Silence was considered essential as noises from machinery and vibration would be objectionable during meetings. All equipment in the various heating units was placed on floating type sound proof platforms and care used in designed ducts to prevent velocity around corners and angles causing air whistles and to prevent sounds being carried from one room to another.

All toilets and cloak rooms are placed on a separate exhaust system so arranged that whenever a door is open into one of these rooms the air flows into that room and prevents any odor from escaping into a corridor or adjoining room. This is taken care of by a motor-driven fan on the top story through a system of vents discharging the air to the highest roof level. The kitchen exhaust system is planned in the same way, the exhaust fan discharging to atmosphere at a point above the highest roof level.

Radiators are placed in rooms having windows in the exterior walls. These radiators have steam automatically turned on and off by thermostats located in the same room as the radiators. Each radiator is fitted with a vacuum trap. All of the automatic control for radiation and dampers throughout the building is of the two pipe, air system type with compressed air for operating furnished by a motor-driven, automatically controlled air compressor.

Ice water drinking fountains are installed throughout the building, water for these fountains being cooled in a tank in the basement and kept in continuous circulation by centrifugal pumps through cork covered pipe. This water is cooled by a direct expansion ammonia refrigerating system. Space is provided for a refrigerating system for the kitchen, but as yet this equipment has not been installed.

Although the power plant has been in operation only about five months it has given entire satisfaction. Sufficient data has not been obtained, however, to ascertain the amount of saving which will be effected over purchased power but from the results so far it is apparent that the cost of operation will come well within the engineers' estimate.

Plants Give Data on Water Screens and Walls

Heat Absorption Equivalent to Over 2000 Per Cent Rating Has Been Measured in Water Screens Which Have Revolutionized Furnace Construction in the Past Few Years

EXTENSIVE INTEREST being taken in this type of furnace protection is reflected by the fact that either water screens are already in use or trial installations are about to be made by 70 different companies recently canvassed by the N. E. L. A. As a result of this wider application, considerable experience in the design and operation of water screens and walls has been assembled.

Originally developed as a protection for ash pits in furnace refractory walls on pulverized fuel furnace boilers, furnace water screens have recently been extended in use to all types of firing, and have been increased in area so as to enclose almost completely the combustion space. Although their original purpose was the reduction of furnace maintenance, the surface has proved to be such an effective and efficient heat absorbing medium that some installations are being made with this viewpoint alone. The cooling property of water cooled walls by reducing furnace temperatures has also been effective in reducing slag formation and in lowering stack temperatures.

Heat absorption to over 2000 per cent rating has been measured at Cahokia Station. At this rate of heat transfer, absolute elimination of scale and ample water circulation so as to limit the proportion of steam in the tubes are necessary if bags and blisters are to be

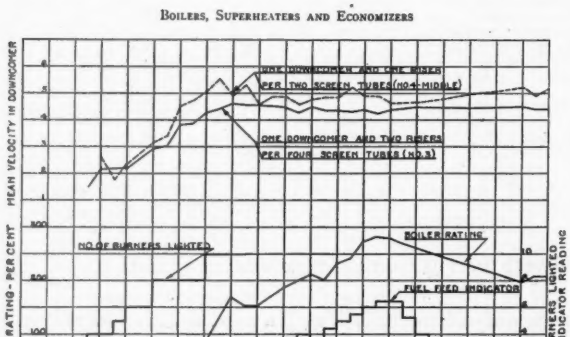

BOILERS, SUPERHEATERS AND ECONOMIZERS
MEAN VELOCITY IN DOWNCOMER
ONE DOWNCOMER AND ONE RISER PER TWO SCREEN TUBES (NO 4 MIDDLE)
ONE DOWNCOMER AND TWO RISERS PER FOUR SCREEN TUBES (NO 3)
BOILER RATING - PER CENT
NO OF BURNERS LIGHTED
BOILER RATING
FUEL FEED INDICATOR
BURNERS LIGHTED 9:15
JUNE 3, 1926
NO. BURNERS LIGHTED
FUEL INDICATOR READING
TIME - A.M.

FIG. 1. SCREEN TUBE WATER VELOCITIES AND PERFORMANCE DATA AT LAKESIDE STATION

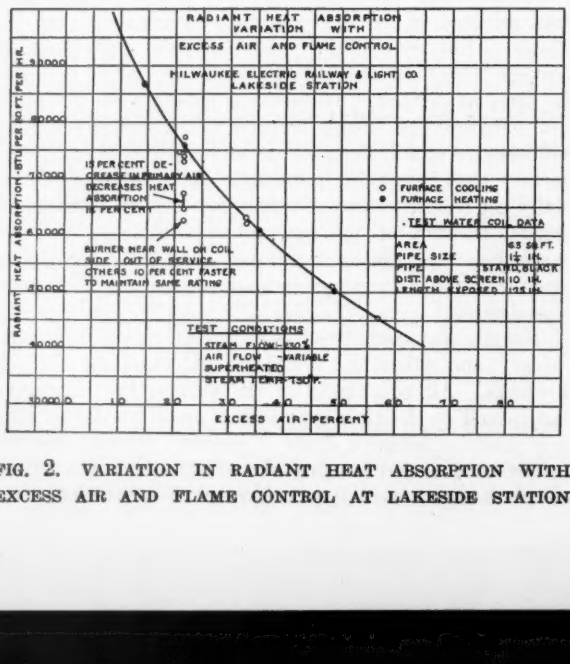

RADIANT HEAT ABSORPTION VARIATION WITH EXCESS AIR AND FLAME CONTROL
MILWAUKEE ELECTRIC RAILWAY & LIGHT CO. LAKESIDE STATION
RADIANT HEAT ABSORPTION - BTU PER SQ FT PER HR.
15 PER CENT DECREASE IN PRIMARY AIR DECREASES HEAT ABSORPTION 15 PER CENT
BURNER NEAR WALL ON COIL SIDE OUT OF SERVICE. OTHERS 10 PER CENT FASTER TO MAINTAIN SAME RATING
FURNACE COOLING
FURNACE HEATING
TEST WATER COIL DATA
AREA 63.56 SQ. FT.
PIPE SIZE 1½ IN.
PIPE STAND. BLACK
DIST. ABOVE SCREEN 10 IN.
LENGTH EXPOSED 175 IN.
TEST CONDITIONS
STEAM FLOW - 250%
AIR FLOW - VARIABLE
SUPERHEATED
STEAM TEMP. 150°
EXCESS AIR - PERCENT

FIG. 2. VARIATION IN RADIANT HEAT ABSORPTION WITH EXCESS AIR AND FLAME CONTROL AT LAKESIDE STATION

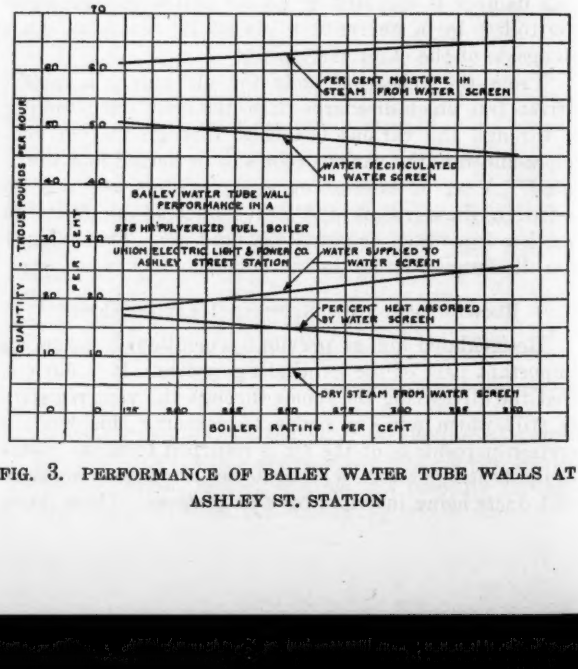

QUANTITY - THOUSAND POUNDS PER HOUR
PER CENT
PER CENT MOISTURE IN STEAM FROM WATER SCREEN
WATER RECIRCULATED IN WATER SCREEN
BAILEY WATER TUBE WALL PERFORMANCE IN A 325 HP PULVERIZED FUEL BOILER
UNION ELECTRIC LIGHT & POWER CO. ASHLEY STREET STATION
WATER SUPPLIED TO WATER SCREEN
PER CENT HEAT ABSORBED BY WATER SCREEN
DRY STEAM FROM WATER SCREEN
BOILER RATING - PER CENT

FIG. 3. PERFORMANCE OF BAILEY WATER TUBE WALLS AT ASHLEY ST. STATION

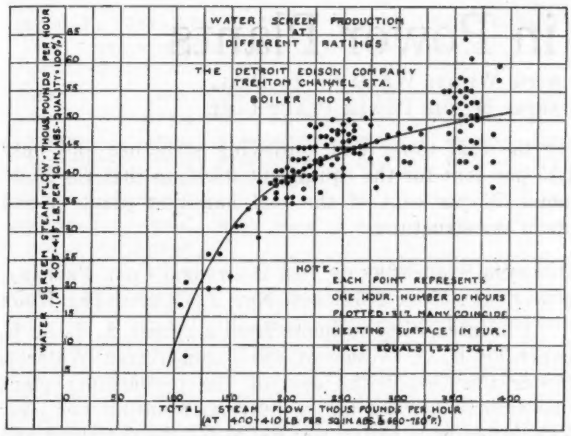

WATER SCREEN PRODUCTION AT DIFFERENT RATINGS
THE DETROIT EDISON COMPANY TRENTON CHANNEL STA.
BOILER NO 4
NOTE - EACH POINT REPRESENTS ONE HOUR. NUMBER OF HOURS PLOTTED WILL MANY COINCIDE
HEATING SURFACE IN FURNACE EQUALS 1550 SQ FT.
WATER SCREEN STEAM FLOW - THOUS POUNDS PER HOUR (AT 400-410 LB PER SQ IN ABS - DUALITY - 100%)
TOTAL STEAM FLOW - THOUS POUNDS PER HOUR (AT 400-410 LB PER SQ IN ABS & 460-150°F)

FIG. 4. AVERAGE RATES OF HEAT TRANSFER IN WATER SCREENS AT TRENTON CHANNEL STATION

avoided. A separate feed water connection at Trenton Channel Station and special castings at Lakeside reduce hydraulic resistance at the entrance of the tubes and are examples of designs leading to positive or increased water circulation.

Frequent blow-downs of water screens separately from boiler water mains is required. Blow-downs should be made when the boiler is down in order to avoid upsetting water screen circulation. In pulverized fuel furnace firing the position of the flame relative to the water screen is important.

Tests at Cahokia station showed 30 to 60 per cent less heat absorption when the flames were shortened to prevent them from entering the screen tubes. Inspection at Lakeside station showed considerably lower temperatures with the screen tubes when the flame is kept above them. It therefore became a regular operating procedure to use only the portion of furnace above the water tubes for combustion and boiler efficiency had to be improved to obtain easy adjustment for complete combustion at all times.

Excess Air Has Material Effect on Heat Absorption

Screen tube water velocities and performance data at Lakeside Station is shown in Fig. 1, while the effect of excess air upon radiant heat absorption at the same station is shown in Fig. 2. This indicates a rapid variation in radiant heat absorption with varying excess air. If the newer type furnaces can be operated with a minimum excess air the costly radiant heat surfaces installed in such furnaces can be made to work at higher rates. Insertion of a special test coil at various lengths through a refractory side wall showed no constant variation in heat transfer as the end of the coil approached the center of the furnace. This indicates that radiant heat transfer near refractory walls is fully as high as that near the center of the furnace. Complete stoppage of an end burner and increasing the feed to the other burners 10 per cent to compensate the coal feed gave a 13 per cent decrease in heat absorption in line with the inactive burner.

In the Ashley St. Station the Bailey wall construction is in use in twenty 5580 sq. ft. boilers. The curves in Fig. 3 represent the performance of these walls. No effort was made to convert the data into rate of heat

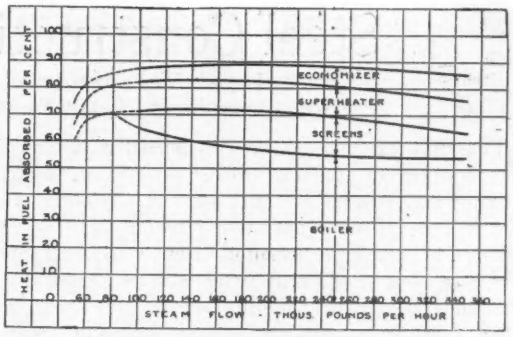


FIG. 5. DISTRIBUTION OF HEAT ENERGY RECOVERED IN TRENTON CHANNEL STATION

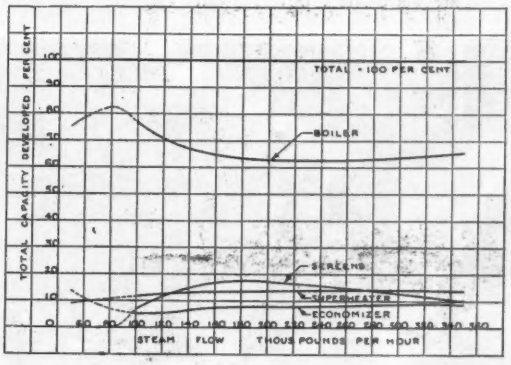


FIG. 6. PERCENTAGE OF BOILER CAPACITY DEVELOPED IN VARIOUS PARTS OF THE UNIT

transfer, as the area to be considered as water screen surface is a matter of question. If it is to be considered the area of the Bailey wall exposed to the surface the heat transfer amounts to 15,000 B.t.u. per sq. ft. per hr. At this rate no trouble has been experienced with the water-cooled walls.

Heat absorption in No. 4 boiler water screen at Trenton Channel Station is shown in Fig. 4 while the distribution of heat energy recovered and capacity developed in the entire unit is shown in Figs. 5 and 6. The data are based on measurements obtained with a flow meter and the results are believed to be accurate within 5 per cent. The water screens installed at this station may be compared to separate boilers in that the screen receives its feed water in the same way that the boiler does, from the plant feed water system. It is not tied in with the main boiler except that the steam generated in the screen discharges to a stop and check valve to a steam drum in the main boiler.

Dry Ice

In the article on the above subject published on page 947 of our September 1 issue, credit for the development of heat absorption by the direct use of solidified gas was given to Arthur D. Little, Inc. We are informed by that organization that this credit was incorrectly placed.

Exercise care in cutting gaskets and making up pipe joints; it pays.

Steel Construction in Power Plants

STEEL IS THE MOST IMPORTANT ITEM WITH WHICH WE HAVE TO DEAL. STRUCTURAL WORK ALONE FORMS A QUARTER OF THE POWER PLANT COST

DIVIDED into four major classifications, boiler room equipment, turbine room equipment, building structure and general expense, costs of a modern power plant will be about equal among them. These figures must not, of course, be accepted literally to mean that in every case each of the four items will be 25 per cent of the total. The general classification does, however, point to the relative importance of the building from an investment standpoint, and reminds us that the architect and structural engineer have a considerable interest in the finished product. Turbine room and boiler room equipment, which the power plant engineer is inclined to regard as the power plant, is, in effect, but half of the total when viewed through the eyes of the accountant.

FIG. 1. STEEL CONSTRUCTION MAKES POSSIBLE THE ERECTION OF LARGE BOILER UNITS WITHOUT DEVOTING EXCESSIVE SPACE TO SUPPORTS AND SUPPORTING MEMBERS

Design, local conditions and geographical location are the determining factors in any given plant, ranking in importance in the order given. Costs of two recently completed central stations, Holtwood and Richmond, are given in Table I, with cost as a percentage of the total. Land costs are not included in the tabulation. For Richmond the general expense item includes the cost of site improvements and sub-structure, but the general expense of field and office engineering, purchasing, accounting, insurance and general construction costs have been distributed. For Holtwood station the item of 25.5 per cent includes this expense and gives a closer approximation to the statement made in the first paragraph. Some $150,000 (4.12 per cent) expended at Holtwood to connect the steam and hydro stations electrically have been omitted in the tabulation.

Structural and equipment cost at different parts of the plant vary. For instance, 12.40 per cent of the cost of Holtwood was expended in the pulverized coal preparation house, 5.53 per cent in the structure, and 6.87 for the equipment. Structural costs amounted to 44.5 per cent here, against 21.7 per cent for the entire plant. At Richmond, where stokers were used, the ratio is even higher, 3.64 per cent of the total being expended for the coal tower and conveying structure and only 1.15 per cent for the equipment itself, so that for Richmond 76 per cent of the coal handling plant is tied up in the structure.

BUILDING STRUCTURE OF THE HOLTWOOD COAL PREPARATION PLANT COST $8720 PER NET T. OUTPUT PER HOUR

It is interesting to quote from a recent A. I. E. E. paper by F. A. Allner of the Pennsylvania Water & Power Co. that "The cost of the preparation plant (Holtwood) per net ton of pulverized output per hour on a bituminous rating was $8720 for the structure and $10,830 for equipment, or a total of $19,550." This amounts to approximately $22 out of a total of $177 per installed kw. which the plant cost. Of course, when making comparisons of this kind for both Holtwood and Richmond, the fact must be kept in mind that parts of the station are built to handle the ultimate capacity and unit costs on future sections will be much lower.

TABLE I. COMPARATIVE COSTS OF TWO RECENT CENTRAL STATIONS GIVEN AS A PERCENTAGE OF THE TOTAL

	Holtwood Station	Richmond Station
Capacity	Kw.	Kw.
Present	20,000	100,000
Ultimate	120,000	600,000
	Per Cent	Per Cent
Boiler room	27.4	23.9
Turbine room	25.4	33.5
Building structure..	21.7	30.9
General expense	25.5	11.7
Total	100.0	100.0

Perhaps one of the main reasons for the popularity of steel in power plant construction is the small space required. This is especially true around boiler rooms, crane columns and long span roof trusses. Figure 1 shows the comparatively open construction possible in boiler rooms even when supporting columns must come down through the room. Reenforced concrete for boiler supports would be out of the question because of the size and space requirements necessary.

Columns, truss, girder and stiffener design, as well as bolt and rivet stresses are well taken care of by various standard specifications such as that of the American Institute of Steel Construction. Where members are subject to heat a factor of safety should be included. Henry L. Doherty & Co. make it a practice to reduce all stresses 25 per cent where heat will be encountered.

Foundations for turbines, which were formerly constructed entirely of reenforced concrete, now often consist of a steel super-structure resting on a concrete substructure. Figure 2 shows the design and arrangement for a steel base under construction for a 30,000-kw. unit.

Even in reenforced concrete foundations, the amount of steel used is considerable. Table II gives the cost of a reenforced concrete foundation for a 25,000-kw. turbine in the Island Station at St. Paul, for which

TABLE II. DETAILED COSTS OF A REENFORCED CONCRETE FOUNDATION FOR A 25,000-KW. TURBINE

Item	Total	Labor	Material	Ins. & Misc.	Unit Quan.	Unit Cost
Form	$3076.72	$2240.25	$680.00	$156.47	5950 sq.ft.	$ .517
Concrete	2307.71	637.49	1636.32	33.90	205 cu.yd.	11.25
Reinforced Steel	1397.61	363.80	1008.09	25.72	285.67 cwt.	4.89
Structural Steel	35.93		35.93			
Total	6817.97				205 cu.yd.	33.08
Bed Plate	976.60	285.47	680.65	10.48	113.46 cwt.	7.32
Total	7794.57					

Toltz, King & Day were engineers. This foundation rests on a gravel and sand stratum which has been figured as having a safe bearing of 2.5 t. per sq. ft. The concrete mixture was 1:2:4 with about 8 per cent of hydraulic lime. With this we can compare in a general way the cost of one of the 50,000-kw. unit steel concrete bases at Trenton Channel plant which is shown in Table III.

Steel-Concrete Bases Give More Room for Equipment

Weakness of the concrete arch over the surface condenser and lack of room at both the steam and generator ends is largely responsible for the adoption of the steel-concrete base rather than the reenforced concrete base by the Detroit Edison Co. At the Trenton Channel

TABLE III. SEGREGATED COSTS OF A STEEL AND CONCRETE FOUNDATION FOR A 50,000-KW. TURBINE

Steel—141 t.	$ 7626.00
Form timber	109.00
Concrete—240 cu. yd.	1434.00
Reenforced steel	342.00
Misc. material	1160.00
Labor—14,738 hr.	12,164.00
Total	$22,835.00

plant the bleeder heaters and an evaporator are placed at the steam end of the base with the air coolers at the generator end. Had this been an all concrete base, an entire re-arrangement of piping would have been necessary and, no doubt, the turbine room would have had to have been made wider. Furthermore, it is possible to

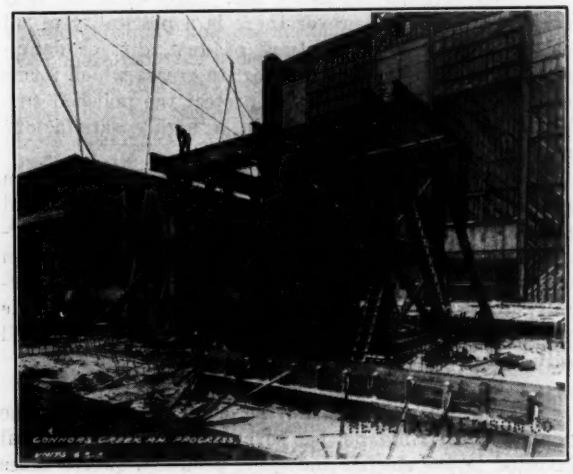


FIG. 2. ERECTING A STEEL BASE FOR A 30,000-KW. TURBO-GENERATOR

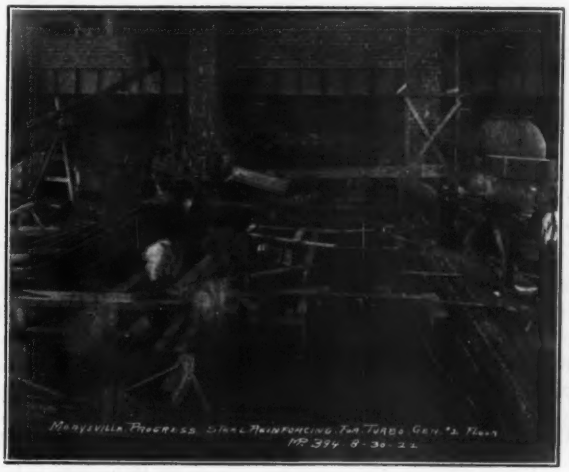


FIG. 3. REENFORCING STEEL IN A TYPICAL TURBINE ROOM FLOOR SLAB

jack up the bases of the steel concrete type in case of settlement, a real danger in Detroit where foundation conditions are not of the best.

Proper erection of the steel base in the field must not be overlooked if vibration is to be cut to a minimum. Holes punched in the shop should be reamed in the field before riveting and column bearing plates must be parallel in order to give full contact with the supporting plates. This can best be accomplished by first milling the bearing plate and temporarily bolting it to a masonry plate with about ½ in. of steel shims in between. Form holes are then drilled through the three members for jack bolts and the columns plumbed by means of them. After the main members have been riveted to the columns the masonry plate should be grouted in.

When proceeding with the design of the steel base a foundation print of the turbine, a drawing of the condenser with a general idea of the main piping is necessary in order to locate the column centers. A box shape is preferable for these members as cross bracing is readily attached and if vibration develops the column can later be filled with concrete.

In this connection tests made at the Ohio State University with gunite coated beams are of interest to show the increased strength of steel properly covered with concrete. The results are given in Table IV. A is the calculated value of a new 22-in. beam based on an elastic limit of 36,000, B is the actual load at which a new beam failed bare, while C is the load at which a similar new beam failed when covered with 2 in. of gunite reenforced with mesh. Column 2 gives practically the same data for old 21-in. beams, B is for the beam bare, C for a beam encased in 2-in. of mesh reenforced gunite and D and E are tests on two more old beams after the lower flanges had been reenforced to make up the steel deficiency below that of a new beam of the same type, all parts being encased in 2 in. of gunite.

Girders across the neck of the condenser require careful attention as the space is limited and they must be designed to prevent uplift of the turbine flange in case the unit operates non-condensing. In addition to the total dead and live loads the Detroit Edison Co.

TABLE IV. TEST RESULTS SHOWING THE COMPARATIVE STRENGTH OF BARE AND CONCRETE-COVERED BEAMS

	22-in. beam		21-in. beam	
	pounds	per cent	pounds	per cent
A Calculated results.	155,600	110.5		
B Actual test results	140,850	100	84,300	100
C Actual test results	222,000	157.5	166,900	198
D Actual test results			227,950	270.5
E Actual test results			223,000	264.5

allows 50 per cent for impact. The steel top or cap must be designed to carry this full load and, in addition, a concrete floor slab poured as deep as conditions will permit in order to keep the center of gravity as high as possible.

Crane Rail Supports Must Be Carefully Laid Out

Crane rail supports are another item requiring careful attention. Figure 4 shows a number of methods of support considered good, the one on the right being considered the best, although it is the most expensive.

Welding Gives Promise of Reducing Building Costs

No doubt the application of welding to power plant structures will be rapid once the practicability of this method of construction is thoroughly demonstrated. Recent developments along this line have been most promising. It is reported that a 1,250,000-cu. ft. building has been fabricated entirely by arc welding with an approximate saving of 11 per cent weight over standard riveted construction. Eleven-ton riveted plate girders are reported reduced to 9 t. when properly designed for arc welding. This is but 82 per cent of the former weight. As yet, however, welding in power plants is confined largely to repairs, low pressure piping and tank work. It is largely used to replace calking, for making tight joints and in fabricating special shapes.

For fireproofing steel members concrete should be a 1:2:4 mix or better and should not be less than 2 in. from the outside surface of the nearest surface of the steel. It is desirable to reenforce this fireproofing with mesh when subjected to heat regularly. Comparative tests made at 1700 deg. F. by the fire underwriters on a 1½ in. thick gunite slab and by the Bureau of Mines on a brick slab 4 in. thick showed that it required 104 min. for the cement and 86 min. for the brick to reach a temperature of 300 deg. on the unexposed face. This demonstrates the superiority of concrete for this service and shows that 2 in. should give as positive a protection as it is possible to obtain economically.

Steel, brick and tile for walls and trimming are almost universally used although wood for doors, frames and interior partitions, other than fire walls has not disappeared. Figure 5 is an excellent picture showing completed and partially completed steel works, concrete forms and frames, finished concrete, as well as exterior and interior brick and tile trimming and steel window frames being placed in position.

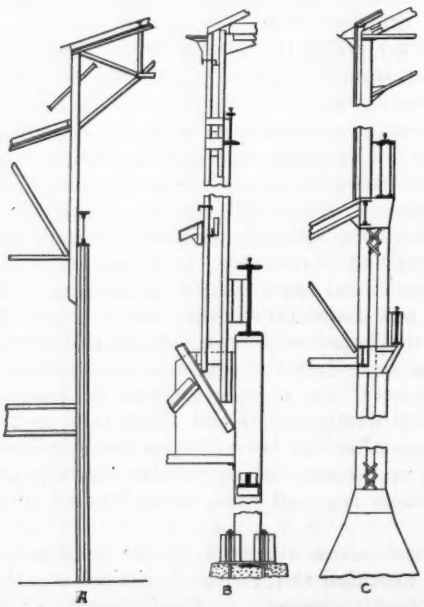


FIG. 4. SEVERAL DIFFERENT COLUMN CONSTRUCTIONS CONSIDERED SATISFACTORY FOR CRANE SUPPORTS

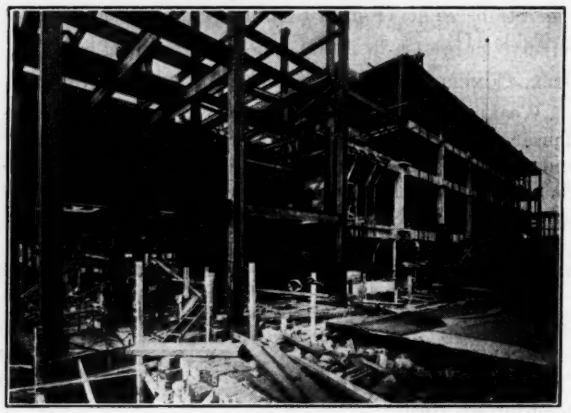


FIG. 5. CRAWFORD AVENUE STATION UNDER CONSTRUCTION SHOWING PRACTICALLY EVERY PHASE OF THE WORK

As a general rule, as light a lubricant should be used as can be successfully retained in the bearing with the temperatures and pressures involved. An oil with a viscosity of from 100 to 200 sec. Saybolt at 100 deg. F. will be best. Wherever there is a possibility of oil leakage however, or conditions of dust, dirt or dampness, it may be advisable to resort to grease which forms better seal, thereby serving to protect the polished surface of the bearing element in a highly satisfactory manner.

Grease can also be more effectively retained in a non-oiltight housing but, on the other hand, dirt and grit which finds its way into a grease lubricated bearing has no means of settling out, but is always held in suspension, being carried back to the bearings repeatedly, unless the design of the bearing is such that the old grease can be periodically forced out and replaced with new.

The United States, having about three times the population of England, has seven times as much capital invested in the electric industry, produces twelve times as much electrical energy, which is sold to ten times as many customers.

Power Plant Piping Needs Regular Inspection

Discussion of Considerations Necessary for Continuous, Reliable Service and Methods of Avoiding Difficulties. By Guy B. Randall*

THERE ARE only two ways of operating a power plant. The one is the *wait-until-it-breaks method* in which only the emergency brings action—action that is often both frequent and expensive. The other is the *inspection method* which is predicated on knowing conditions and making them meet a service standard. Of all the divisions of the power plant benefited by the inspection method none responds more promptly in dollars saved and service rendered than the pipe and valve system. Yet piping is generally regarded as being so simple that it often receives only such attention as its failures demand. There is no real effort made to secure the maximum of service at the minimum total cost. Sired by a draftsman and damned by a repair man, the system may be regarded as being born, bred and governed by mechanics—less often by engineers. Yet today so great is the range and variety of piping materials and equipment that it is safe to say no part of the power station responds more to competent engineering either from a design or an operative standpoint. This applies not only to the new project but to the old system which can, with economy, be brought up-to-date.

Mechanical and Analytical Consideration

You cannot inspect a piping system regularly without involuntarily dividing the work into two classes. First there is the simple repair and maintenance class. This covers a wide range of leaks, deposits in the lines, corrosion, insulation, worn parts, etc., and is usually very simple to handle. It is chiefly a mechanic's job. Then there is the inspection that is essentially scientific in its attitude. It is made with a view to improving conditions, not merely restoring them. It involves the research type of mind. But, as Charles Kettering has emphatically pointed out, this involves no "high-brow" personage or equipment as research of great value may be conducted by a man of ordinary intelligence with a blow-torch and a pair of tinners' snips. Furthermore, a full-fledged power plant is a full-fledged laboratory in a great many ways. In it proper periodic inspections will reveal many new angles and facts which the equipment manufacturer is not in so good a position to get.

Perhaps this research type of inspection may best be exemplified by recounting a few cases which have a direct bearing on many similar problems. Cast-iron valves and fittings are commonly regarded as satisfactory for all steam temperatures to 500 deg. F. But periodic inspection of some valves and fittings in a plant with 450 deg. F. temperature showed there was a marked tendency toward growth in the cast iron of certain makes of valves. The valves did not leak badly. Some engineers and operators would have considered them reasonably satisfactory. It was the attempt to maintain a high standard of inspection and service that brought out the trouble. Personally the writer feels that ordinary cast-iron valves and fittings should not be used on temperatures over 400 deg. F. A reliable semi-steel is probably good up to 500 deg. F. These figures are the result of considerable observation. Possibly cast iron can be made which will endure 20 yr. more service at 500 deg. F. The writer, however, does not consider it good engineering to depend on it as foundry practice varies and it takes 20 yr. to find out if it was good practice. Inspection may also reveal that the particular variety or extent of wear on a valve may make advisable a change in the make or the type. A change in the type of blowoff valves in one case resulted in a very striking reduction of costs. The blowdown duty was severe and a change to a disc type valve which could be refilled easily with lead made it practicable to change the disc every three months at negligible expense and insure tight valves all the time. The re-leaded discs were not allowed to go until they leaked. They were changed on a regular schedule. The same idea applies to the packing of valve stems. It is frequently or even generally cheaper to maintain a fixed schedule for renewing these packings than to let them go until a valve stem is cut due to excessive pulling on the gland or a prolonged leak. This in turn implies proper condition of the back-seat to give latitude in scheduling the time for the work. It goes without saying, of course, that valves which are not regularly operated should have a definitely scheduled "open and close" time as an inspection service to know they are all right. It is also good for the valve.

Insulation Difficulties Present Drawbacks

Possibly one of the greatest drawbacks to sound valve and pipe inspection practice is the covering of heat insulation. Up to the present time there has been no alternative but to tear it off, get everything covered with it, put it back, and clean up. However, with the advent of more durable as well as more efficient types of insulation it will probably not be long before such covering will be suitably cased for easy application and removal. It would not seem difficult to standardize this material except for the valves themselves. But if each valve maker was expected to furnish his own valve insulating shell (of a sectional type) the problem would be solved. The present methods of applying insulation not only inhibit general inspection and repairs but act as a medium for outside corrosion. The spongy insulation holds moisture from a leak and the oxygen from the atmosphere does the rest. Inspection against this is an important service. Lines that carry cold or cool liquids are particularly subject to attack. Generally speaking, cold water insulation is applied so thinly that the outside of the insulation (which is not water tight) gets cool and condenses atmospheric vapor. Where sufficient thickness is used the breathing at joint causes the same trouble. In addition to thicker multi-layer insulation with lap joints the writer has found that in certain cases application of no-corrosive greases to the pipe itself (before covering) to be well worth while.

This fragmentary discussion of power station piping has merely attempted to cover some of the high spots of the problem which have been emphasized very little or not at all. Power plant piping is now going through a stage of development closely akin to that the station

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wiring and control boards went through a short time ago. With the growing complication of the piping system and the increasing importance of the service a great deal of new methods must be learned and applied. But even more important than this is to raise the standard of operation of present systems. The value of clean steam and treated water is not fully appreciated. The writer ascertained several years ago that steam of less than ten parts per million impurities was practicable and feasible but he does not believe (in spite of the volumes of printed matter) that there are half a dozen stations in the country that will qualify on an annual basis. Central stations running on a full surface condensing basis are sometimes among the worst offenders although the industrial plant with ninety per cent make-up is not to be defended. Tons of dirt running riot through the ramifications of a vast pipe system is not a thing to be lightly disregarded. Neither is the carelessness often displayed by modern pipe fitters. What is needed in pipe management is not only the better use of existing new ideas and new things but the rejuvenation of some old ideas and old standards of workmanship —a rejuvenescence of the commonplace along with the use of 1927 equipment.

Recent Development in Pulverized Coal Burning

EXPERIMENTS BY U. S. SHIPPING BOARD AND U. S. NAVY ESTABLISH METHOD OF SUCCESSFULLY BURNING PULVERIZED COAL IN BOILERS HAVING COMBUSTION CHAMBERS OF SHORT LENGTH AND SMALL CAPACITY

DEVELOPMENTS which give promise of affecting the use of pulverized coal in stationary power plants, have recently been made by the Fuel Conservation Section of the United States Shipping Board, of which C. J. Jefferson is head, in collaboration with the Fuel Testing Plant of the Philadelphia Navy Yard. These developments are the result of investigations made to discover an efficient method of burning pulverized coal in the marine boilers with which ships are now fitted.

LOWER COST FAVORS PULVERIZED COAL

It was recognized that fuel oil is ideal in many ways for steam generation, but its cost restricts its use. Moreover the unstableness of its price, due to lack of serious competition in its production, would deter sole dependence upon oil as a fuel supply in any large field because, on its adoption, an advance in price would be expected. Besides its ease of handling and efficient burning, oil has a further advantage over all solid fuels for shipboard use in that it may be stored and easily removed from space such as the extreme bottom of the hull, which is not otherwise usable except for ballast. By storing the oil in compartments and refilling each compartment with water as it is emptied of oil, liquid ballasting may be, at least in part, employed.

Comparing the burning of pulverized coal of 14,400 B.t.u. to bunker oil of 18,300 B.t.u. it was found that about 5 per cent of the steam generated is required in the pulverizing and distribution process in the former case, while 2 per cent is required in the latter case for introducing the oil into the furnace. One pound of oil, therefore, has the comparative effectiveness of 1.36 lb. of coal. But the oil costs $11.60 a ton while the cost of the coal is $6 a ton.

Year by year it is becoming increasingly difficult, particularly under conditions obtaining in marine service, to secure men with sufficient skill to swing on a slice bar and at the same time have enough mental energy to care anything about saving heat units. It is increasingly difficult to drive men when the heat of the fires is burning up the human part of their minds. Substitution of the use of pulverized fuel, therefore, which permits of complete mechanical handling, represents an important advance in marine practice.

But 85 per cent of the ships afloat are fitted with Scotch marine boilers, each having three furnaces with separate combustion chambers. These furnaces, because of their low volume and short length, are entirely unfitted for the combustion of pulverized coal as usually fired in stationary practice. The problem then resolved itself into a redesign of the furnace and of the method of introducing the pulverized fuel.

In the average pulverized fuel plant, where the rate of combustion has been less than a pound of fuel per cubic foot of furnace volume, deep or long furnaces have been used. These allowed flame travel of 20 ft. or more and permitted comparatively slow flame propagation, or ignition of the individual particles of coal. This type of furnace design is not practical on shipboard and in the case of the Scotch marine boiler. It is not only impractical, but impossible. The furnace of a Scotch boiler may be made smaller, by installation of refractory lining, by accumulation of ashes and dirt, or by the collapse of the furnace, but it just cannot be made larger.

Ordinary Scotch boiler design calls for a furnace which is approximately 8 ft. long up to the combustion chamber which is about 3 ft. deep, giving a total maximum length of flame travel of 11 ft. In fact, this should be reduced to about 10 ft., as impingement of the flame against the rear sheet of combustion chamber must be avoided. This gives one phase of the problem. The flame length must be cut in half, as compared to the ordinary stationary plant. The combustion space in a three-furnace separate combustion chamber type of Scotch boiler of 2500 sq. ft., heating surface, which is the typical type of boiler found on the average cargo carrier, will be somewhat less than 500 cubic feet. In order to burn 2000 lb. of coal per hour in these furnaces, 4 lb. of coal per cu. ft., or approximately twice as much as the maximum rate or eight times as much as the average rate attempted in the stationary plant, must be burned. All this must be done in a completely water cooled furnace without the benefit of stored up heat found in the refractories of the large furnaces in stationary practice. The difficulties encountered by the investigators will now be appreciated.

On account of the small combustion space and short flame travel existing in these boilers, initial tests with stream line burners were not successful. The maximum rate of combustion that could be obtained was 2.5 lb.

of coal per cu. ft. of furnace volume or a heat release of 32,000 B.t.u. per hr. per cu. ft. of furnace volume at a boiler efficiency of only 54 per cent. The burner in these initial tests was installed vertically and consisted of four nozzles so arranged that the stream of coal, together with the air necessary for combustion from each of these nozzles, would cut the stream issuing from the adjacent nozzle, thus setting up a terrific turbulence. This type of burner has all of the air necessary for combustion used as primary or carrying air, and any attempt to regulate the air supply would have a direct effect on the turbulence produced, and inasmuch as an air swept ball type of mill was used to pulverize the coal, it would also have a direct effect on the fineness of the coal delivered.

No air heaters nor superheaters were fitted to the boilers used in the initial tests but an air heater was installed later as it was apparent from the former tests that all measures should be taken to speed up flame propagation, and one of the means of accomplishing this end, is to have the air necessary for combustion heated to as high a temperature as possible before it enters the furnace. The use of heated air in the pulverizer mill also reduces the variation in the fineness of coal caused by moisture in the fuel.

Fineness and Uniform Quality Necessary

Uniform quality of coal of sufficient fineness to insure satisfactory ignition and complete combustion is of paramount importance in connection with the use of pulverized fuel in marine boilers, just as is the case in regard to the correct viscosity of fuel oil. In the stationary plant a much wider latitude in degree of fineness is permissible inasmuch as, in the large volume furnace with the long flame travel, the coarser particles of the fuel may be ignited farther along in the flame travel and while in the earlier part of the flame the efficiency of combustion may be relatively low, this is compensated for by completion of the combustion in the latter stages. In the marine boiler, this is not permissible, the limited length of flame travel making it imperative that complete ignition take place as soon as possible, and that efficient combustion start during the very early stages.

Tests, recently completed, which were initiated by Capt. C. McAllister, were conducted by the U. S. Navy under the joint direction of Commander J. S. Evans and of C. J. Jefferson. The equipment included a Scotch marine boiler having 2550 sq. ft. heating surface, a Kennedy-Van Saun pulverizer and a Peabody burner and distributor. In these tests, as much as 2400 lb. coal was burned per hour per boiler, 6 lb. being burned per cubic foot of furnace volume. Coal having a volatile content varying from 17 to 35 per cent were successfully burned. The results from these tests are now being calculated, and will form the basis of a technical paper that will be presented at the November meeting of the Society of Naval Architects and Marine Engineers.

Further tests are to be run under sailing conditions on the S. S. "Mercer" which is now being equipped with a Kennedy mill, Peabody burner and distributor and Link-Belt crusher and conveyor, for this purpose.

Stationary practice recently has been tending toward reduction of furnace volume and of flame length by the application of turbulence during the admission of pulverized fuel to furnaces; the results of the investigations mentioned will, therefore, be anticipated with great interest.

Economical Operation of the Hand-Fired Plant

Satisfaction and Economy Can Be Obtained by Use of Proper Boiler Settings, Good Firing, Suitable Dampers and Use of a Few Extremely Simple Instruments Such as the Draft Gage. By R. C. Demary*

OF THE ESTIMATED total of 135,000,000 t. of coal used in the states of Illinois, Indiana, and Ohio during 1926, at least 18,000,000 t. were used in plants which were hand fired and developing an average of 250 hp. It is reasonably safe to state that not one in ten of the plants consuming this 18,000,000 t. of coal had modern equipment or any apparatus whereby a check on their operation could be made.

In a survey conducted by the author in one of the largest cities in Ohio, it was found that the greatest losses were due to excess air, low settings and dirty tubes. Other losses found were caused by uncovered pipes, leaking steam lines, low temperature feed water, and generally poor regulation.

The externally-fired, brick-set, h.r.t. boiler is the type generally found in the hand fired plant of small capacity. While not so efficient as the water-tube type, it holds its popularity because of its low cost and general simplicity. There have been practically no changes in the construction and but few changes in the setting of this type of boiler.

It is usually set, even today, as shown in Fig. 1; this is known as the Hartford setting, designed for burning anthracite, which was the common fuel in the East many years ago.

As manufacturing moved westward into the bituminous fields, the h.r.t. boiler came with it and also the low setting. The kind of coal to be used seems never to have been considered and the result was that the setting shown became general in all districts.

In Fig. 1, the distance between the grate and the boiler shell is usually found to be between 28 in. and 30 in. and only rarely is it found to be as much as 36 in.; the combustion chamber is almost always filled in and covered with brick as shown.

This setting is not bad where anthracite or coke is to be used but it is the most undesirable setting that could be devised for bituminous coal or any long flaming fuel.

Figure 2 shows an approved setting, where the minimum distance from the shell to the grate is 48 in., the recommended distance being 60 in. to 72 in. for a 72-in. diameter boiler.

To secure any degree of economy, combustion must be as complete as possible. This requires room for, in

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burning bituminous coal, if the flame strikes the relatively cool surfaces of the boiler, combustion is checked and smoke and soot are formed. The soot clings to the metal surfaces of the boiler and acts as a heat insulator. We always think of asbestos as being a good insulator and so it is; however, 1/5 in. of soot on the heating surfaces of a boiler will equal one inch of the best asbestos. Certainly we would be severely criticized were we to insulate our boiler heating surfaces with asbestos one inch thick.

The combustion chamber of a boiler has three purposes: 1—it acts as a chamber in which combustion may be completed if unfinished in the furnace proper; 2—it traps the fine ash carried over by the gas flow and prevents to a certain extent its deposit in the tubes or flues; 3—it acts as an expansion chamber and tends to

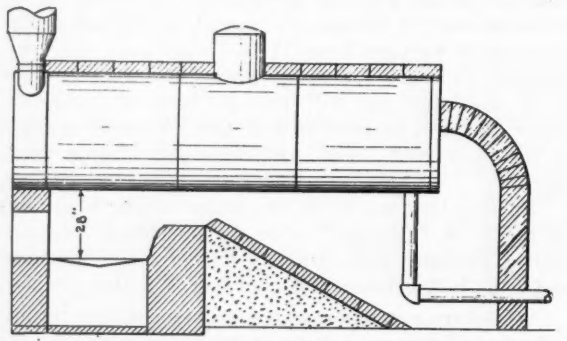


FIG. 1. HARTFORD SETTING FOR H.R.T. BOILERS DOES NOT GIVE ENOUGH COMBUSTION SPACE FOR BURNING BITUMINOUS COAL

delay the passage of the hot gases, insuring absorption of more heat through the boiler shell.

Do not make the mistake of filling up your combustion chamber for the purpose of holding the flame against the boiler shell. Naturally, with the higher settings mentioned there may be a greater loss of heat through the furnace walls and boiler front but this will be offset by better combustion and a considerable gain in economy will be noted.

In many installations, especially the older ones, little thought was given to head room at the time of installation, therefore the setting and construction are such that it is impossible to raise the boilers, to provide additional combustion space. It is often possible, however, to lower the grates without making any change in the boiler front or setting. This is accomplished by using a "depression plate," as shown in Fig. 3.

Thus it is possible to secure an increase of 6 or 8 in. between the grates and the boiler shell. While this is not sufficient to meet ideal requirements, it will greatly improve the combustion efficiency.

Reduction of Excess Air Is Important

After doing all that we can to increase the furnace volume and combustion space we must cut down the excess air. Excess air is the power plant thief that we fear the most. What is meant by excess air is that air entering the furnace and combustion chamber through the setting, grates, or other places and which is in excess of the amount required for proper combustion. This is the greatest enemy to fuel economy and efficiency with which we have to deal and I have found it the most common.

The entire setting should be well covered with one of the numerous insulating plastics which are on the market. They are usually composed of asphaltum and asbestos fiber. When applying this material be sure that the brick work and the metal parts of the setting are well bridged over, for at these places we find the most serious air leaks. The material is cheap, easy to apply and in most cases will pay for itself within a few weeks.

At one plant in this city the cost of covering the brickwork was $42.60 and the amount of coal saved was 1700 lb. a day of 12 hr. The coal cost was $5.25 a ton in the boiler room. Certainly this was a saving worth making and it has been duplicated in a great many cases.

Get the Draft When It Is Needed

We know, of course, that we can not burn fuel without air or, more correctly speaking, draft. The draft in which we are most interested is the draft in the furnace where the fuel is burned. If we have sufficient draft in the up-take to remove the burned gases and the air mixed with them we need not be particularly interested in the chimney draft. There may be a very good draft at the chimney base, where no fuel is burned, and little draft at the furnace where it is needed.

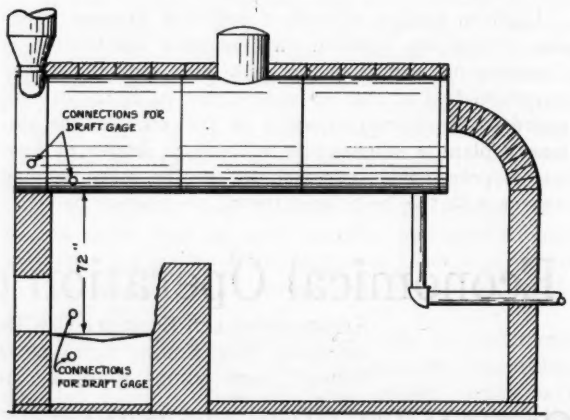


FIG. 2. FOR A LONG FLAMING FUEL, SUCH AS BITUMINOUS COAL, THIS SETTING IS RECOMMENDED

A short time ago the writer was called to a large office building where the superintendent said the tenants were complaining of not having sufficient heat. He had tried various grades of coal and he said the fuel he was getting was no good, for it would not burn with any life. A draft gage placed at the base of the stack showed nearly 2 in. and in the uptake of the boiler the gage showed only 0.06 in. Was it any wonder that the fire appeared dead and generated but little heat? Leaks were found in the breechings, brickwork, and boiler front. These were calked, the draft in the furnace rose to 0.75 in., and no further trouble was experienced.

Another case in which the writer was called proved rather interesting. It was that of another office building and the plant consisted of three 72 in. by 18 ft. h.r.t. boilers. The stack was smoky and in fact the entire equipment was condemned by the engineer. The boiler room was located in the sub-basement quite a distance below the street level and the writer noted that when

entering the boiler room that there was a strong rush of air through the door when it was opened.

Investigation showed that the boilers were trying to operate while the gage showed 0.01 in. of vacuum and two boilers were in use at all times. The doors were all opened and the skylights as well; the vacuum disappeared and a draft of about 0.05 in. was obtained. The air coming in as it did, however, was such that a fireman could not be expected to stay on the job. So a large, sheet-metal air duct was constructed leading to the light shaft and coils inserted whereby the air could be heated. This was so placed that the air was diffused against the ceiling, avoiding strong drafts in the boiler room. After this installation the draft in the furnace was found to be 0.20 in. and one boiler was ample to heat the entire building in the severest weather. Incidentally, the fuel bill was reduced nearly one-third.

In the first case mentioned there was too much air and in the second not enough sufficient air to support combustion properly.

As we proceed to attempt to increase the efficiency of our plant it will be necessary to purchase some instruments, the cost of which is not great and which will pay handsome returns on the investment.

Importance of the Draft Gage

One of the first instruments purchased should be a good differential draft gage—one for each boiler—so connected that it will read not only the chimney draft but the furnace draft as well. The proper connections are shown in Fig. 2. In my work many complaints are received of poor draft and in nearly every case the chimney gets the blame; however, I have not as yet been called on a case where the chimney was not found to be all right. I have found chimneys that were declared faulty pulling about four tons of useless or excess air to every ton of necessary air. The trouble was with the engineer, not the chimney.

Recently a complaint was made to our department that one of two boilers scaled so badly that weekly cleaning was necessary, while the other boiler would be in good condition after five or six weeks' operation. Both boilers used water from the same source and operating conditions were apparently the same. Every one connected with the plant had voiced his opinion and as a last resort, the City Combustion Engineer was called. A draft gage was connected and it was found that one boiler (the one that was scaling) was doing just about four times the work of the other boiler. Dampers were conspicuous by their absence and this meant that there was no way to control the draft. The first recommendation was the installation of dampers in the uptake of each boiler, so constructed as to be easily operated from the boiler front. Draft gages were then purchased and the draft of each boiler regulated so that each was doing its share of the work. This put a stop to the scale trouble at once and a large saving in fuel has been reported to the department.

Surely no argument is needed in support of draft gages. We know that there is some draft that will burn our fuel with the greatest efficiency and still carry our load. There may be too much draft or not enough, but there is some point between these extremes where there is the best draft. That is the draft we should use. Just what that draft is depends on the fuel we are using, its size, ash and water content and the thickness of the fuel bed. There is a definite relation between fuel resistance, draft and load. I have already stated that the draft should be measured at the furnace instead of at the stack or damper for the reason that the fuel is being burned in the furnace and it is the draft applied there that determines the rate of combustion. It is important sometimes to know the draft resistance or loss through the boiler, but this loss has no effect on the combustion efficiency, provided there is sufficient draft in the furnace to produce efficient combustion.

The real difficulty is to educate the fireman to use the gage. He must be shown that a draft gage will give him instant notice of any change in the fuel bed. If the fuel is too thick on the grates or if the fire is dirty, the gage will show an increase in the draft. If the fire is too thin or if there are holes in the fuel bed, a decrease in draft will be noticed. A good fireman watches his draft gage just as closely as his steam gage and fires by it. There should be a draft gage on each

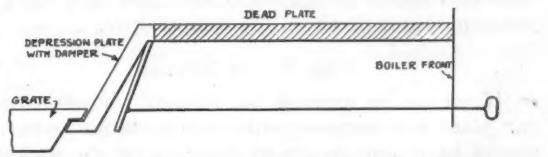


FIG. 3. IF A CHANGE IN THE BOILER SETTING CANNOT BE MADE, COMBUSTION CAN OFTEN BE IMPROVED BY LOWERING THE GRATES WITH A DEPRESSION PLATE

boiler for the same reason we have a steam gage on each boiler.

There is one general rule used by the combustion engineer which is: *Use that draft which will produce complete combustion with the minimum amount of air and still maintain the steam pressure.*

The Use of Dampers

Only in a few cases are dampers found to be in working order, and even then they are seldom used. They are of great importance in securing good combustion. Dampers for h.r.t. boilers should occupy the full width of the opening and have a free area at least 25 per cent in excess of the tube area. The controls should be brought to the front of the boiler so they may be easily reached by the fireman.

Never use the ashpit doors for draft regulation. It is true that closing the ashpit doors cuts down the air supply and reduces the rate of combustion, but the draft in the setting is increased and more air is drawn into the furnace through all parts of the setting, out of all proportion to the coal burned. Naturally one must use high draft with high rates of combustion, and low draft with low rates of combustion. I have frequently found, where the ashpit doors were used instead of the damper, that 40 to 50 lb. of air were being used where it should have been not more than 15 or 18 lb.

Feed Water Heaters

It is surprising, when a survey is made of plants of 250 hp. and under, to find how many are operating without any means of heating the feed water. It is well known, or should be, that heating boiler feed water by means of exhaust steam effects a fuel saving of about 1 per cent for a rise in temperature of about 11 deg. F.

Increase in boiler capacity is in about the same proportion as the fuel saving. Raising the feed water temperature from 50 deg. F. to 210 deg. F. will save about 1/7 of the fuel and increase the boiler capacity about 1/6.

While the type of heater best adopted is always the cause of some discussion, there is no question as to the greater economy of an open heater over that of the closed type. The heat in the condensate from the exhaust steam is saved in the open heater and lost in the closed. To make 7 lb. of hot boiler feed water in a closed heater requires 7 lb. of cold water and 1¼ lb. of steam, while with an open heater it will require only 6 lb. of water and one pound of steam, assuming the water to be raised from a temperature of 50 deg. F. to 210 deg. F. in both cases.

Where there is a feed water heater in use it is only on rare occasions that you find a feed water thermometer. Of course, the thermometer will not make the water any hotter but it will indicate just what the opportunities for saving really are. Not only that, but you can keep a check on the temperature.

Feed Water Meters

If we are to increase the economy or efficiency of our plant and compete with central station power, we should have some means of determining the weight of fuel used and the weight of water evaporated. If we have these figures we can easily determine the over-all or combined efficiency of the plant, which is useful at all times. It enables us to compare the efficiency of one day or shift with that of another.

A short time ago the owners of a local plant were confronted with the choice between erection of a new power plant and purchase of power from a central station. While the plant had always been kept in good condition no means were available of computing the cost of power with any degree of accuracy.

It was only after much talk and figuring that the writer convinced the owners that a new and modern plant should be erected. The old plant consisted of two h.r.t. boilers 72 in. by 18 ft. and set 30 in. above the grates. The new plant consists of two water tube boilers rated at 250 hp., set 7 ft. above the grates. Draft gages, water meters, feed water thermometers, automatic soot blowers and damper controls brought to the front of the boiler form a part of the equipment. With this installation the engineer took an added interest in the plant and he can at all times keep a careful check on its operation.

Several tests have shown that the new plant is producing considerably more power than the old one at a much lower cost. The new plant is putting current on the switchboard for ½ cent kilowatt-hour less than the rate quoted by the central station. The engines are operated during about 8 mo. of the year on a back pressure of 4 lb. and the exhaust steam used for shop heat.

I can not agree with those who say the day of the small plant is doomed, for it has been repeatedly demonstrated in my work that they can successfully compete with purchased power. Owners of power plants must be educated, however, to the fact that the power plant is not a necessary evil to be placed in some out of the way place or in some corner of the building not suitable for anything else.

It will pay big returns on the investment when properly operated, and equipped with such instruments as to eliminate the guess work.

There seems to be a prevailing idea among power plant owners, even in states and cities where there is a license law in effect, that any man can operate a boiler or engine. This is a great mistake. A good engineer and fireman are a necessity. Their surroundings should be clean and their welfare is just as important as that of any of the other employes. Their pay should be commensurate with their work.

These points might be illustrated by a recent occurrence that was brought to my attention in connection with my official duties. Owing to a slack period it became necessary for a certain plant to cut expenses and, as usual, the power plant was the first to suffer. The fireman was notified that he would have to take a cut of 10 cents an hour, with the result that he quit. I strongly advised against this cut as I was familiar with the condition and knew they were making a mistake. A new man was put in charge and it was not long before complaints were filed in my office. I went to the plant and after checking it over I found the new man was using, on an average, 1700 lb. of coal more each 10-hr. shift than the old man and the load was considerably lighter. While the company was paying one dollar per day less in wages, it was spending $4.46 more for coal. Certainly this was false economy yet similar cases are frequently encountered in my work and there is no doubt that they exist in every city.

Oil Engine Costs

At a meeting of the electrical section during the convention of the Wisconsin Utilities Association held at Madison, Wisconsin, on Sept. 2, 1927, C. J. Virgin referred to a survey of oil engine costs in 51 plants in which the average cost per kilowatt installed capacity was $182. This cost included buildings, auxiliaries and electrical equipment.

"Maintenance costs in oil engine operation," he said, "are rather difficult to get at due to the great variations in maintenance costs in individual installations. It was found in the survey which our people made, covering 63 plants, that the average maintenance cost was 3.3 mills per kw.-hr. generated. Fifty-four plants are reported as having an average maintenance cost of $8.11 per kw. installed. Seventy-two per cent of the 54 plants reported above had maintenance costs in excess of $3.00 per kw. installed and 54 per cent had costs over $5.00 per kw. The figures just given in most cases are based on results obtained during one year; they cover, however, quite a wide variety of plants with regard to capacity and age and are reliable as a guide as to what may be expected in the way of maintenance. A cost of 2.64 per cent of the cost of buildings and engine is reported as maintenance for 25 plants."

For the City of Saskatoon, McClellan & Junkersfeld, Inc., 68 Trinity Pl., New York, has recently completed a preliminary report on extending the municipal power plant, including a study of the possible amalgamation of water works and power plant.

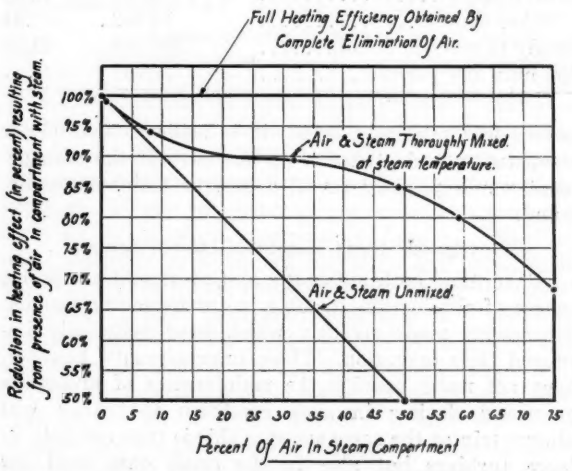
Intermediate Steam Pressure Field Invites Study

USE OF STEAM AT PRESSURES BETWEEN 10 LB. AND 150 LB. FOR INDUSTRIAL PROCESS WORK HAS CREATED NEW PROBLEMS IN STEAM DISTRIBUTION. BY MORRIS A. HALL

USES OF STEAM are so widely known that it may come as a surprise to many engineers, manufacturers and others contacting with it in some form to learn that a distinctly intermediate pressure field of use exists. This calls for different technique, knowledge, equipment and methods.

From the first low-pressure engines, steam power producing units have grown and expanded. Pressures have increased rapidly with this steady expansion until today, in current engineering and manufacturing circles, the words "high pressure" refer rather to pressures above 250 lb. than below it.

In this high-pressure field, methods for generation, distribution and use of steam are highly perfected.


Full Heating Efficiency Obtained By Complete Elimination Of Air.
Air & Steam Thoroughly Mixed at steam temperature.
Air & Steam Unmixed
Reduction in heating effect (in percent) resulting from presence of air in compartment with steam.
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
Percent Of Air In Steam Compartment

EFFECT OF AIR ON HEAT EMISSION FROM STEAM CONTAINER WITH ATMOSPHERIC PRESSURE INSIDE CONTAINER

Many engineers specialize in this field alone. Some manufacturers produce equipment or apparatus solely for high-pressure use.

Probably the second great use for steam was that of heating. The development of this field, however, took a wholly opposite trend as regards pressure. Steam at moderate pressure was used in the beginning and the tendency toward the lower end of the scale has constantly increased. Engineering and manufacturing efforts have been directed toward effective heating with lower and lower pressures and have been successful. The development of the vacuum system of steam heating has brought with it wide engineering knowledge of methods for the generation and distribution of steam at so-called "vapor pressures." It is now common practice to heat large structures with only ounces of pressure. As a result, when one speaks of "low pressure steam" the phrase rarely refers to pressures above 10 lb.

THIRD GREAT FIELD OF STEAM USE

Between these, the low pressures extending from 10 lb. downward and the high pressures extending from 250 lb. upward, a third field has developed rapidly but almost unnoticed. Yet it is found to be tremendously important, almost as large as either of the others.

Certainly, few have considered this intermediate field as a whole. It is now possible to do so, for the analysis of pressures and temperatures as well as the breadth and scope of this field, indicate that it is distinguished by its own problems, distinctive pressures, and apparatus or equipment designed wholly and exclusively for use of steam at these intermediate pressures. This field is the use of steam at pressures between 10 and 100 (or 150) lb.

Because steam within this middle range, neither high nor low by present day understanding, is used so much in various industrial and non-industrial processes, the comprehensive term of "process" steam will be used to describe and explain it.

Examination of methods and equipment for handling steam at these process pressures shows that they have tended to lag behind the standards maintained in heating (or low-pressure) and power (or high-pressure) practices.

RESEARCH CLASSIFIED THE PROBLEMS

Recently, research engineers in the heating industry have begun to assemble the components of this newer field, classify them into proper logical groups, and study the problems involved. Heating engineers have taken the lead in this, which was logical since the problems were closely akin to those of low-pressure heating. In many installations, the engineers have had to work with both low pressures for heating and intermediate pressures for process apparatus.

In the study of steam utilization it is convenient to break the subject down into three parts: generation, distribution and use.

There is no particular problem about process steam generation because high-pressure steam generating plants are suitable, reducing valves or non-condensing and back-pressure prime movers providing the desired lower pressures.

Similarly, the matter of use presents little difficulty. It is tied rather closely to the design of the steam-using apparatus in question. Designers of process steam equipment have been successfully working along well defined lines.

PROCESS STEAM DISTRIBUTION NOT SIMPLE

When we turn to process steam distribution or circulation we find a different condition. Users have been left to shift for themselves. Methods of insuring complete, correct circulation at these intermediate pressures they have had to work out in their own ways. Manufacturers of machinery using process steam have not always been able to call in steam specialists for working out their problems.

Heating engineers have long known that satisfactory and efficient steam distribution depends largely upon provision for positive removal from apparatus and pipe lines of air and water of condensation on the one hand, and prevention of the escape of steam of water containing unused heat, on the other.

Those who have given the closest attention to these

matters say that the importance of free and continuous discharge of air from the interior of the apparatus has not been, and even now is not being, fully appreciated. It leaks into the steam compartments when the equipment is cold and must be discharged completely before full operating efficiency can be realized.

The more quickly this discharge can be accomplished the sooner will the apparatus reach its maximum output. In some cases air continues to enter the apparatus, and is carried over in mixture with the steam. It is a poor medium for the transmission of heat and so long as it exists within the apparatus in air-bound pockets or in mixture with the steam, will reduce the potential output. The effect of such air mixture on the rate of steam transmission is shown in the accompanying diagram.

This general analysis of the problem of handling process steam is put forward in the hope that it will stimulate further study along these lines by designing, testing and operating engineers.

Operators Demand Quick Starting Turbines

THERE IS A DEFINITE DEMAND FOR MACHINES WHICH CAN BE STARTED AND PLACED IN SERVICE QUICKLY AND WHICH WILL GIVE FEWER VIBRATION TROUBLES WHEN TAKEN OUT OF SERVICE FOR SHORT PERIODS OF TIME

DURING THE PAST year, many of the difficulties encountered in the operation of large turbines have been overcome as a result, in part at least, of the closer cooperation between the operators and the manufacturers. There is, however, according to an N. E. L. A. report still considerable room for improvement and a definite demand on the part of operators for machines which can be started and placed in service quickly and which will give fewer vibration troubles when taken out of service for short periods of time. It seems, however, that such machines are possible only at a sacrifice in efficiency, therefore there is nothing in view at the present time which promises materially to reduce this difficulty in large, high efficiency turbines.

Operating records from a number of large turbines where operation with steam pressure is considerably higher than those which had previously been used and for operation on the reheating cycle showed such favorable results that it is laid to developments of similar units of higher capacity. Operating records of 191 turbines installed in the United States of capacities above 20,000 kw. are given in the table. This record shows an increase in the per cent of total time over the previous year that the units were unavailable for service due to the combined outage of turbines and generators. It also shows an increase in the capacity available when compared with results in the 1924 report.

Approximately 37 per cent of the outage hours due to the turbines were caused by annual inspection and adjustment. This same item of inspection and cleaning accounted for 20 per cent of the generator outage hours, while armature windings and field windings accounted for 13 and 19 per cent respectively. Of the total condenser outage hours, cleaning is charged with 66 per cent and tubes with 14 per cent. Among the miscellaneous causes of outage general piping is charged with 24 per cent and electrical plant to 31 per cent.

Data on the operation and maintenance of turbines used for auxiliary drives are given in the report and, while this maintenance as reported by the member companies was relatively small, it is believed that closer co-operation and attention on the part of the management would possibly reveal a greater maintenance demand.

AN ANALYSIS OF 191 TURBINE INSTALLATIONS GIVING THEIR OPERATING RECORDS

	Hours	Per cent
No. turbine units	191	...
Installed unit capacity	5,626,850 kw.	...
Total period hr. reviewed	1,625,438	100
Kw-hr. generated—total	21,241,886,600	...
Service hr. demanded	1,111,813	68.42
Service hr. operated	1,058,018	65.08
Idle hr.	567,420	34.92
Steam turbine	114,535	7.05
Generator	29,639	1.82
Condenser	58,093	3.58
Other causes	14,769	.91
Ready to start in 30 min	350,384	21.56
No. unit idle periods	27,761	...

GOVERNORS STILL REQUIRE IMPROVEMENTS

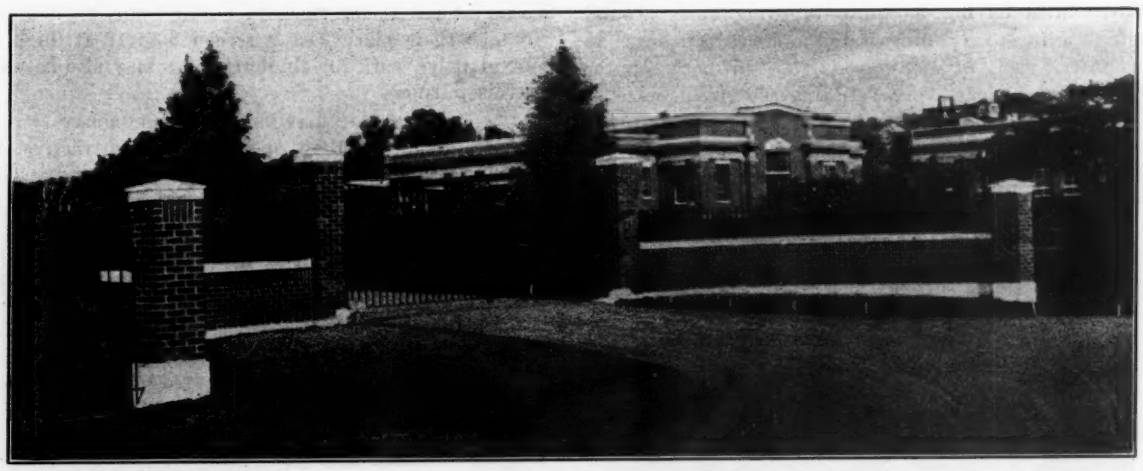
Governors, both automatic and overspeed are still a source of considerable trouble, notwithstanding the improvements made recently which have materially improved their operation. These improvements, however, have not made possible the maintenance of automatic overspeed devices in such condition that they will always trip at the same speed. This is true not only in large turbines but also in the small ones used for auxiliary drive.

During the past few years the vibration of a number of large turbines has given considerable trouble. This in some cases has been traced back to the foundation footing having a tendency to vibrate with the same frequency as the turbo generator. The results of investigations have disclosed the need of a more thorough study of this characteristic of foundations as, at the present time, very little is known of the subject. Some work has been done abroad but in this country it has only recently been started. The problem is important and can be solved only through close co-operation with the manufacturing and operating companies.

CONTRACT HAS BEEN let and plans announced by Chaplin-Fulton Manufacturing Co. for a new four-story plant and office building at 38—40 Penn Ave., Pittsburgh, Pa., on property adjoining the present factory. William McKee, president of the company, states that the building will be started at once and will be in use by Jan. 1, 1928.

In addition to the new structure, a full story will be added to the entire present plant, giving 100 per cent increase in capacity, necessitated by a growing volume of business.

IT NEVER pays to take things for granted; investigate and be sure.



Beautiful Surroundings Are an Asset to Industry

ADORNING THE POWER PLANT GROUNDS WITH TREES, SHRUBS, VINES AND FLOWERS WILL REFLECT TO THE PASSERBY THE ENGINEERING SKILL DISPLAYED WITHIN THE PLANT

IS ENGINEERING a profession devoid of culture—that development of human faculties which makes for an appreciation of intellectual accomplishments without monetary remuneration as the chief objective? Must we, in our endeavor to economize and conserve, strip all our industrial enterprizes of beauty? We think not. Industry is a human invention and institution. Likewise power plants using the laws and materials of nature have been built and developed as a result of human ingenuity. They are operated by human beings who have the same desire for the development of their human intellectual faculties as do others of our race. Perhaps the power plant industry is still too young to have put on the cloak of respectable surroundings, but we believe the time has come when power plants should be looked upon as places of general interest, if not beauty, in a community, instead of avoided because of their unsightly surroundings.

Wherever human beings must work their surroundings should be attractive because of the culture and interest value. Without such surroundings work to many, who enjoy beauty as expressed in architecture, landscape gardening, flowers and shrubs, becomes a monotony with one purpose only—a means of living. Probably the housewife knows best the value of environment. She endeavors to make her home the most attractive place possible, not only to the head of the house but to the children so that they would rather be at home than anywhere else. Industry cannot, of course, go to the same lengths as the home but in many factories desirable results have been secured through landscaping the surroundings, providing recreation grounds, organizing clubs, orchestras and choruses for promoting culture. Some factories have found it profitable to install phonographs and radios in their work rooms to be used during working hours.

Few people are content to work for wages alone but workmen place different values upon the cultural environment about them. As a rule, however, the men with higher mental training place greater value on aesthetic surroundings than do those whose training has been purely manual. So, if the power plant industry wishes to draw to it men who have the brain capacity to apply scientific principles to their work, it behooves the managers of this industry to look carefully to their surroundings, otherwise the men they desire and need in their power plants will be attracted to other fields.

The question is asked, "How can this be done?" The answer is too broad for consideration in any one article so we shall confine ourselves to only one phase, that of beautifying the grounds around power plants.

LANDSCAPE GARDENING OF PUMPING PLANT GROUNDS

Several years ago the writer visited the Des Moines, Ia., Pumping Plant which left such an impression that on every occasion he has pointed to it as almost ideal in surroundings. Located in the river bottom, the plant was virtually surrounded by a marsh until somebody conceived the idea of excavating part of the grounds to build up the remainder. In this way, two lagoons were formed around which shrubs, trees and vines have been planted in such an arrangement as to give a most pleasing sight from early spring to late fall and, even in winter, the bushes covered with snow or sleet present a view well worth seeing.

In decorating the banks, the plants used consist principally of sumacs, willows, elders, dogwoods, viburnums, hawthorns, wild crabs, perennials and others, most of which are native to Iowa and also most of which were raised in a nursery established on the water supply lands. The large lagoon was stocked with game fish and the small lagoon, which was lined with concrete, contains gold fish. Fountains are provided that are supplied with waste cooling water from the plant. With blue grass lawns, clean macadam roadways and an ornamental fence these grounds are indeed beautiful.

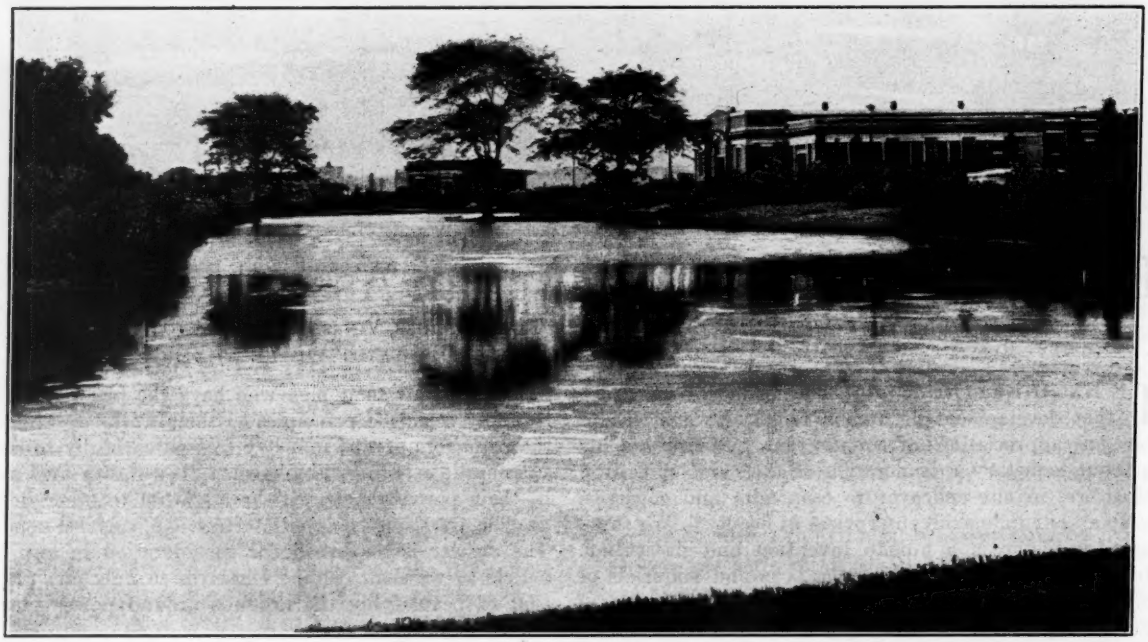
This is, of course, a municipal plant and the city feels the need of a park but the authorities are convinced that to dig the lagoons, landscape the banks and maintain the grounds was less expensive than to fill in the entire grounds which would otherwise have been necessary.

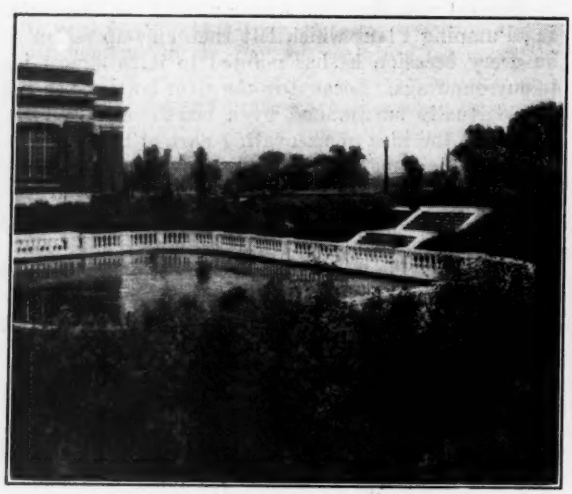
Similar conditions, however, sometimes surround other types of plants and the managers should not be

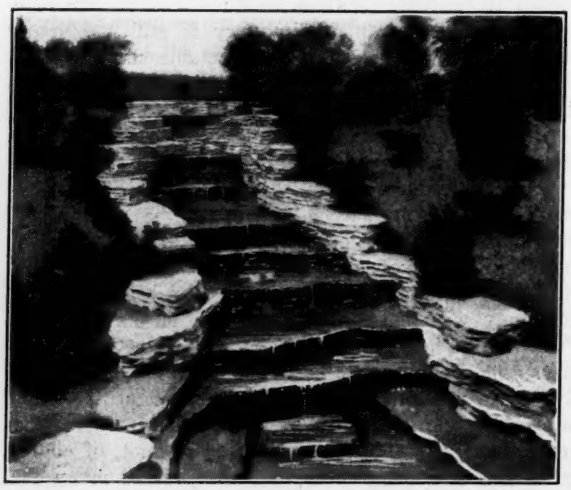
content with having mosquito breeding holes around their buildings. Running water and fish are death to mosquitoes and, in many cases, one or both can be provided at little expense. In Fig. 4, for instance, is a view which could be made beautiful by growing a hedge to take the place of the board fence along the road and taking the tin cans out of the water. As it is, the attractive architecture of the factory building is visibly marred by the neighboring unkempt swamp and ugly fence. Sometimes it pays to keep the weeds down in an adjoining unused lot in order to improve the appearance of the neighborhood. When that cannot be done a screen may be grown which will hide the unsightly objects. Note Fig. 5, the before and after growing a screen. Castor beans make a quick growth and serve such a purpose nicely but are annual plants. Sumac set out at the time the castor beans are planted will take their place with a screen 8 to 12 ft. high in 2 yr. Lattice work for climbing vines may also be used for this purpose.

Protect the Lawns with Shrubbery

A well kept lawn in open spaces is attractive, no matter where the power plant may be located. This can be protected by shrubbery at sidewalk corners or low hedges to prevent the wearing of paths where they are not wanted. In laying out walks, however, much grief can sometimes be avoided by providing gravel paths through the lawn where workmen are most likely to walk. These paths may not be where your aesthetic taste would put them but, with a strip of iris on each side, they are better than a bare path through the lawn which would otherwise be the result.







FIGS. 1, 2 AND 3. THE GROUNDS SURROUNDING THE DES MOINES WATER WORKS HAVE LAGOONS STOCKED WITH FISH, FOUNTAINS, CASCADES, LAWNS AND SHRUBBERY IN PLEASING PROPORTION AND BEAUTIFUL IN COLORING

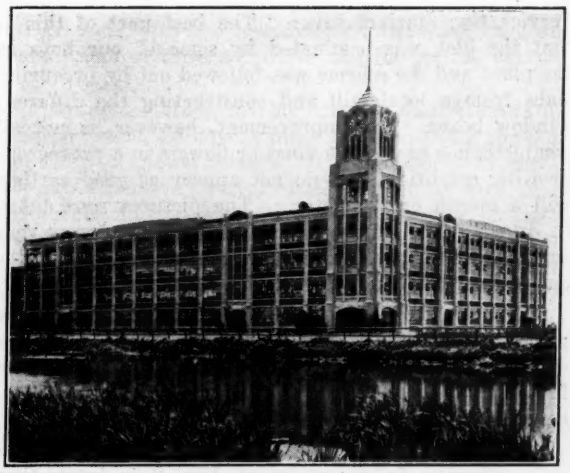


FIG. 4. THE BEAUTY OF THIS ARCHITECTURE IS LOST, DUE TO THE UNSIGHTLY FENCE IN THE FOREGROUND

In spite of all the rules that can be laid down, there are places about power plants where a lawn cannot thrive because of the trucking and teaming that must be done. In such places pavements should be laid or, if that expense is too great, a good thick bed of gravel or crushed stone which will keep down the weeds and will not form dust, has many advantages, besides appearance, over bare ground with its patches of weeds and wheel tracks worked into chuck holes in wet weather. Such yards for temporary storage and hauling should be definitely confined. A decorative fence or one covered with vines will serve nicely or, with a little more care, a well-trimmed hedge may fit the surroundings better. The Tonawanda Power Co. has done this very effectively.

Decorations for Building Foundations

Around the building itself it is not out of the way to provide a gravel path. If you do not, ten chances to one, the workmen will wear one for you and probably track considerable mud into the entrances during the wearing. Next the building, however, low shrubs or

FIG. 5. AN ARTISTIC ARRANGEMENT OF PLANTS AND FLOWERS IS AN EFFECTIVE METHOD OF BEAUTIFYING A REPULSIVE VIEW

FIG. 6. BACK OF THIS SCREEN OF WOVEN WIRE AND SHRUBBERY IS GRAVELLED PARKING SPACE FOR CARS OF THE TONAWANDA (NEW YORK) POWER CO. EMPLOYES

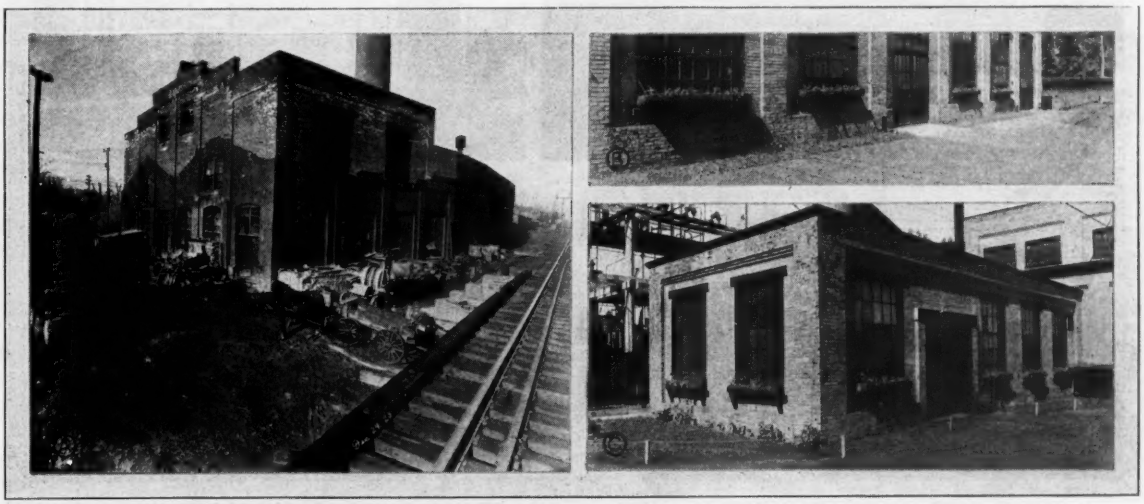


FIG. 7. THIS MIRACLE WAS WORKED WITH GRAVEL, WINDOW BOXES AND PLANTS

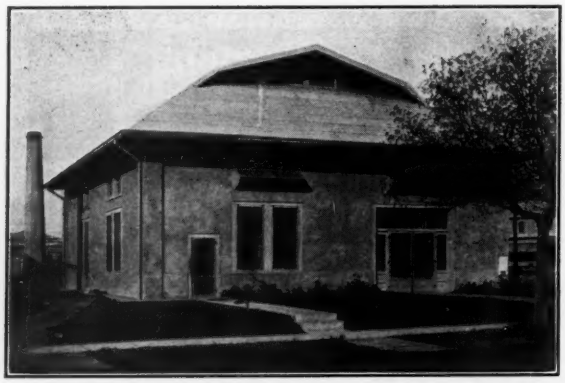


FIG. 8. WITH A RESIDENTIAL TYPE OF POWER PLANT BUILDING THE POSSIBILITIES OF BEAUTIFYING THE GROUNDS ARE UNLIMITED

flower beds under the windows give a pleasing effect and do not interfere with the light. The places for trees are at the corners and in front of bare wall spaces. Trees also show up well in the open spaces in the yard or, where there is a rather long driveway, a row of trees on each side, trimmed high so as not to interfere with trucking, gives a permanent appearance to the property and lends dignity to a well-designed power plant structure.

Such a view as that shown at the left in Fig. 7 is not at all uncommon. We have become so accustomed to such sights that we think the unkempt yard is a necessary part of industry. The pictures at the right, however, show a transformation well worth duplicating at many plants. Mr. Coppock of the Indiana General Service Co., Marian, says: "The best part of this is that the idea was originated by some of our boys at the plant and the scheme was followed out by procuring slabs from a local mill and constructing the different window boxes. The improvement, however, is not all complete, nor are all the vines or flowers in a prosperous growing condition, and do not appear as good as they will a month or two later. (The pictures were taken in June.) The expense of this improvement was very small; I would say, including the labor and plants, the entire cost would not exceed $50."

This, of course, is only a start but the owners are proud of the results and the plant is no longer the eyesore it was. That plant has learned the value of a few floral decorations and we venture to say will never be without them again.

As illustrating a type of plant which has become quite common in recent years, Fig. 8 is interesting. The building itself could almost be taken for a residence, but it houses the Diesel engine equipment that furnishes the town of Crowley, La., with light and power. Here a start has been made at landscaping the grounds. What is proper around any home would be proper here. The lawn and shrubs at the front in no way interfere with the operation of the plant and certainly make the place a much pleasanter abode for the workmen than bare ground with piping, poles and spools of wire thrown upon it.

Southern California has the advantage of a climate where vegetation will grow the year around, nevertheless a few views of what is being done there in the way of landscape gardening may give some ideas that can be worked in other parts of the country. The policy which prevails in this work is to harmonize the buildings

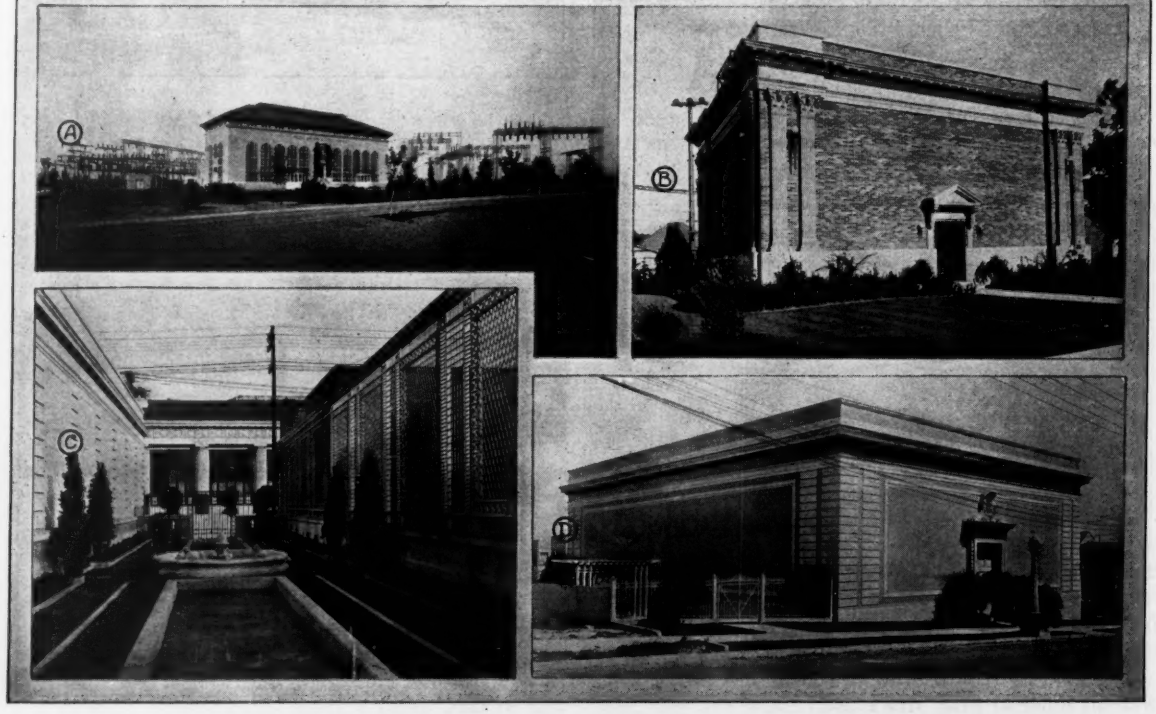


FIG. 9. SUBSTATIONS IN CALIFORNIA HAVE SURROUNDINGS THAT ARE TRULY BEAUTIFUL

and grounds with the neighborhood in which they are located, making them attractive and interesting because of their beauty.

Fountains, statues, marble benches, marble stairs up terraced lawns, all have a place in beautifying the surroundings of power plants but, if properly executed, they are expensive. Nature has provided us with grass and shrubs and trees of almost every variety of color, size and shape from which we can pick and choose and work out our individual tastes at moderate expense. And don't forget the value of flood lights. They are the product of the plant and can be used to advertise the beauty of the premises at night when other places are dark and unattractive. When all these are used with intelligence, our industry, in which we have a just pride, will present beauty spots in the community as well as providing an indispensable utility.

Installation Costs of Diesel Engines

Industrial Plant Installation Costs Are Lower Than Those of Central Stations. By Edgar J. Kates*

CONSIDERABLE data on the initial costs of Diesel generating plants is contained in the table herewith, reprinted from page 675 of the June 15 issue. The cost of each plant is expressed in dollars per kilowatt capacity and has been subdivided into about 25 different items, an unusual but highly commendable procedure. The figures were obtained directly from the books of the operating companies by an investigator of the National Electric Light Association. All of this makes the data worth more than a passing glance, and it is the purpose of this article to attempt to draw from it some conclusions of possible use to a power-user who is thinking of installing his own Diesel plant. Included in the table are a number of items of cost that relate only to electric central stations operating under the supervision of Public Service Commissions. For instance, such items as Nos. 24, 27, 28 and 30, respectively "interest during construction," "engineering overhead," "other overhead," and "25 per cent overhead on specific charges" are usually considered by these commissions as part of the plant investment upon which the central station is to be allowed to earn an equitable return. These four items bulk larger than might be expected; for instance, in the 400-kw. plant known as No. 7 they total $47 per kw., while in the 200-kw. plant No. 6 they amount to $62 per kw. Expenditures of this sort are, of course, seldom incurred in the ordinary power plant built by an owner for his own use.

Comparative Cost Figures Should Be Relevant

Switchboard and wiring cost (Item No. 7) is another figure which, although properly included in the table as an element of plant cost, nevertheless is of no value in estimating the cost of other Diesel plants. The cost of switchboard and wiring bears no relation to the type of prime-mover, but it varies greatly with different local conditions. For example, the table shows the cost of switchboard and wiring to be $15.62 per kw. in a 400-kw. plant, only $5.40 per kw. in a 240-kw. plant, but $31.10 per kw. in a 200-kw. plant. Evidently neither size of plant nor type of engine has anything to do with switchboard and wiring cost.

"Freight and handling, all materials" (Item No. 14) also varies widely, as might be expected. It is only $1.60 per kw. for the 400-kw. plant, rises to $15.60 for the 1000-kw. plant, and drops to $9.70 for the 3500-kw. plant. Figures such as these have no value outside of the particular plants from which they were secured; the cost of freight and handling in any projected plant can be accurately estimated as soon as the location is determined.

Local Conditions Influence Costs

Similar variations exist in most of the other items, and the lack of information regarding the local conditions of each plant makes it perplexing to use the data for estimating the cost of a proposed private plant, where the conditions may be entirely different. Even such definite items as engines and generators vary more than one would expect—the cost of engines, generators and exciters being $93.30 per kw. for the 400-kw. plant, but $100.50 for the 1000-kw. plant in spite of the larger units. This may be partly explained by the fact that the large plant was installed in 1923, while the smaller one was put in in 1925 after there had been a general drop in prices.

Many of the figures seem to be unusually high and the total installation costs as stated are considerably above the figures that have been found in numerous Diesel plants installed for industrial use. H. C. Thuerk, of the Erie Lighting Co., Erie, Pa., after making a

DIESEL ENGINE PLANT INSTALLATION COST IN DOLLARS PER KILOWATT CAPACITY INSTALLED

No.	Item	*Plant Numbers 1	2	6	7	8
1.	Total plant capacity, kw.	3,500	1,000	800	400	240
2.	Date of installation, (approximate)	1916 1921	1923	1925	1925	1925
3.	Engines complete	88.60	97.80	98.20	93.30	89.80
4.	Generators & Exciters complete	20.00	11.00	Incl. in Item 3	Incl. in Item 3	Incl. in Item 3
5.	Cranes	0.70	2.20	.....	.....	.....
6.	Clutches, reduction gears, special drives, etc.	None	None	.....	.....	.....
7.	Switchboard & Wiring	2.20	5.00	31.10	15.62	5.40
8.	Auxiliary power units, air compressors, etc.	None	None	17.60	7.35	5.90
9.	Water pumps; water cooling and softening equipment	0.60	0.70	Incl. in Item 18	Incl. in Item 18	.....
10.	Lubricating oil, separators, purifiers, filters	0.60	0.50	.....	.....	.....
11.	Fuel oil pumping and clarifying equipment	0.20	0.20	.....	.....	.....
12.	Piping complete	4.80	6.00	22.15	14.40	4.23
13.	Shop equipment and tools	Use gen'l. shops	0.20	.....	.....	.....
14.	Freight and handling, all materials	9.70	15.60	3.85	1.60	2.67
15.	Miscellaneous materials	.....	.....	1.41	0.74	0.93
16.	Total machy. and equipment costs	126.90	138.90	174.32	132.99	106.83
17.	Land and titles	no data	no data	not incl.	Incl. in Item 18	not incl.
18.	Bldgs. R.R. sidings, etc.	11.60	30.00	56.60	45.20	.....
19.	Foundations, including muffler pits, pipe trenches, etc.	8.60	10.00	Incl. in Item 18	Incl. in Item 18	4.17
20.	Lubricating oil storage	None	None	.....	.....	.....
21.	Fuel oil storage	0.90	1.20	.....	.....	.....
22.	Superintendence	1.40	2.00	.....	.....	.....
23.	Installation labor (not included above)	7.10	5.00	19.10	13.82	10.20
24.	Interest during construction	7.80	9.40	7.33	3.07	2.67
25.	Insurance (compensation)	Incl. in Item 24	Incl. in Item 24	0.94	0.94	0.25
26.	Acctg. stores, overhead	Incl. in Item 25	Incl. in Item 25	Incl. in Item 25	Incl. in Item 25	1.20
27.	Engrg. overhead	3.10	3.70	19.10	9.06	6.52
28.	Other overhead	.....	.....	26.10	19.35	10.70
29.	Total installation cost as reported	147.40	200.20	303.49	224.65	144.74
30.	Total installation cost allowing 25 per cent overhead on specific charges	196	234	313	240	156

* No data secured for plants 3, 4 and 5, for which data are given in Table II

*Consulting Engineer, New York City.

study of the question, concluded that as an average, the cost of a Diesel generating plant is $160 per kw. for plants ranging in size from 100 kw. to 300 kw. and $150 per kw. for larger plants ranging in size from 500 kw. to 1500 kw. Other estimates run lower. One engine manufacturer recently figured a 1000-kw. two-unit plant, including building, at $142,800, or $143 per kw. A Jersey municipality recently opened bids for a 1250-hp. (850-kw.) Diesel engine completely installed, including building addition and foundation, ranging from $117,962 to $97,862, i. e. from $139 per kw. to $115 per kw. A Texas municipal plant has just bought two 1250-hp. Diesels (without generators) at a price of $58.75 per hp. ($88 per kw.) f. o. b. factory, the bids ranging from $97 per kw. down to $73 per kw.

If, however, a power user is seriously considering whether it would pay to install a Diesel power plant, he can easily settle the question of initial cost. He can obtain bids from engine manufacturers on a complete plant, erected and ready to run, or he can have a consulting engineer lay out a suitable plant and make up an accurate cost estimate. In either case the cost figures will be based on his own local conditions and will therefore be much more accurate than if obtained in any other way.

Diesel Engines for High Speeds; Some Obstacles to Be Overcome

By W. Marx Kaufmann

HIGH SPEED for Diesel engines brings problems not encountered when 300 r.p.m. or lower is the goal. Speeds up to 900, 1200, even 2000 r.p.m., are desired to fit this type of engine for small stationary powers and for automotive work, yet the complexity of air injectors, compressors and other auxiliary equipment, as used for marine work, is out of the question. Nevertheless, Diesel engine designers have tackled this pioneer work and are making notable progress.

For the two-stroke cycle engine, wherein a power impulse is developed every revolution, the small time interval for fuel injection, complete combustion and scavenging was a problem which has been solved with some success by introduction of complete fuel pump timing control and the use of positive displacement scavenging pumps.

The four-stroke cycle type, with power impulse every second revolution, has been more attractive owing to the lower heat stresses due to full scavenging of the exhaust stroke and the introduction of cool air on the succeeding suction stroke. Problems pertaining to volumetric efficiency have been met but by the use of four valves, two inlet and two exhaust, these have been corrected. Light weight pistons of aluminum alloys, capable of withstanding the high compression and firing pressures, and tubular forged steel connecting rods varying from 1/8 to 3/8 in. annular thickness were developed. To conceive the forces involved, let us assume an 8-in. diameter piston with a firing pressure of 750 lb. per sq. in., which is not uncommon practice. The total load on the piston is the pressure per square inch multiplied by the area of the piston, i. e., $(3.1416 \times 8 \times 8 \div 4) \times 750 = 37{,}680$ lb. or 18.84 t.

Ability to withstand this load applied from 500 to 600 times a minute, or an 18.84-t. blow every $\frac{1}{10}$ second, has been proved to a high degree of safety.

Fuel pumps compressing oil to pressures of 10,000 lb. per sq. in., fuel injection nozzles with spray holes of from .007 to 0.020 in. diameter were introduced in an endeavor to reach higher speeds with good combustion.

Experimental activity along these lines has been intense. These are some of the chief difficulties encountered in this pioneer work.

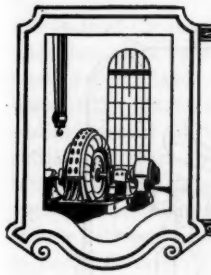
Light Oils from Utah Coal

A study of the composition of light oils from low-temperature carbonization of Utah coal has been conducted by chemists of the United States Bureau of Mines, Department of Commerce, and Carnegie Institute of Technology, Pittsburgh, Pa. This investigation was undertaken because of the need of information on the composition of low-temperature oils and tars in their evaluation by buyers and seller, by producer and user, and others. The investigation was one coordinated with a study of the use of superheated steam as an internal-heating medium in the production of smokeless fuel and with a study of the gases produced during the carbonization and their variation with temperature. The coal used was from the Mesa Verde bed in Utah and was a non-coking coal.

The oil from the gas produced when Mesa Verde coal was heated at a maximum temperature of about 725 deg. C. by means of superheated steam was examined as to its composition. The amount of oil recovered was about 7 c.c. per kilogram of coal or 1.7 gal. per t.

This oil, which boiled from 20 deg. C. to slightly above 200 deg. C., resembled casinghead gasoline in its physical properties, but was unlike it because of its high content of unsaturated hydrocarbons (olefins). It contained about 30 per cent of amylenes, about 10 per cent of pentane, which was largely (about 80 per cent) isopentane. About 26 per cent of the oil was made up of 6 carbon-atom compounds, of which 1/3 was saturated and largely cyclic and 2/3 consisted of a mixture of hexenes. The 7 carbon-atom compounds were estimated to amount to about 17 per cent, of which 2/5 was saturated and consisted largely of paraffins-heptanes and the other 3/5 was divided nearly equally between straight-chain (heptanes) and cyclic olefins. The portion corresponding in boiling range to the 8 carbon-atom hydrocarbons equaled about 8 per cent of the oil. Slightly over half of it possessed the properties of cyclic olefins and the remainder was saturated and about 3/4 naphthenic. The remaining 9 per cent, boiling from 125 deg. C. to slightly over 200 deg. C. consisted of about equal parts of saturated and unsaturated hydrocarbons, possessing the physical properties of the corresponding naphthenic compounds. The amount of acids and bases in the light oils was very slight.

Results of this study are given in Bulletin 31, Mining and Metallurgical Investigations, by R. L. Brown, organic chemist, United States Bureau of Mines, and R. B. Cooper, research fellow, Carnegie Institute of Technology. Copies of the bulletin may be obtained from Carnegie Institute of Technology, Pittsburgh, Pa., at a price of 15 cents.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Improvements in Large Generator Construction

New Skeletonized Frame Stator Construction Permits Complete Assembly and Winding of 75,000-Kw. Stator Before Shipment. By J. R. Taylor*

DURING THE LAST decade, the power developed by turbine generator units has increased from 20,000 kw. to the present projected value of 208,000 kw., now being offered by manufacturers and sought by operators. With large capacity units, the problem of transportation demands increased attention. The railroads are unable to carry units of such capacity, because the weight of the heaviest piece to be transported approaches the limits of wheel loading, bridge capacity, or clearances. The problem must be further considered by the three parties who are involved from the date of sale until the time a unit of such size assumes its part of the system load. A manufacturer desires to fabricate a unit complete in his own shops, because certain positive gains are to be obtained from such procedure. The building is done under shop conditions, which are a closer approach to ideal manufacturing conditions than can be obtained in most power plants. It offers an opportunity for much closer control of the product, therefore an inherently better product. Along with building at the works goes the opportunity to conduct tests which will ultimately result in engineering advance. The manufacturer must consider weight, because it determines works problems of handling and machining large pieces; it involves cost of building of the unit on a dollar per pound basis; and it gives a measure of the designer's ability in the use of materials on a kilowatts per pound basis at a given number of revolutions.

Transportation companies must meet the problem in the light of necessity for new equipment, of how close approach is made to allowable limits on wheel and track loadings, and of what demands are imposed on bridge structures.

Operators must consider weight from the viewpoint of the expenditure of capital required for supporting structures. In the turbine hall, the design of the crane run supports, with the consequent outlay, involves the weight of the heaviest piece to be handled. In addition, the cost of the foundation supports for the unit proper are dependent to a large extent upon the load to be carried.

On large turbine generators, the piece of maximum weight and shipping width is invariably the stator. In order to obtain all the advantages of works built and necessarily light weight machines, and overcome all the disadvantages of heavy weight and consequently outside built machines, a skeletonized frame and sheet steel construction was developed by the Westinghouse Electric & Manufacturing Co. With this method of construction and the use of a special type of low center railway car developed by the Pennsylvania Railroad Co., stators for units rated at 75,000 kw. can be built and wound complete at the works and be shipped ready to set on the customers' foundations. A view of this type car is shown in Fig. 1. The first of this type turbine generator constructed was purchased for installation at Binghamton, New York. According to the terms of the contract, the generator is to be able to deliver 35,295 kv.a. of 3-phase energy at 85 per cent power factor, 13,800 v. and 60 cycles, when direct connected to a 30,000-kw. steam turbine, at 1800 r.p.m., with a temperature rise not to exceed 60 deg. C. by embedded detector on the stator and 90 deg. C. rise by increase in resistance on the rotor.

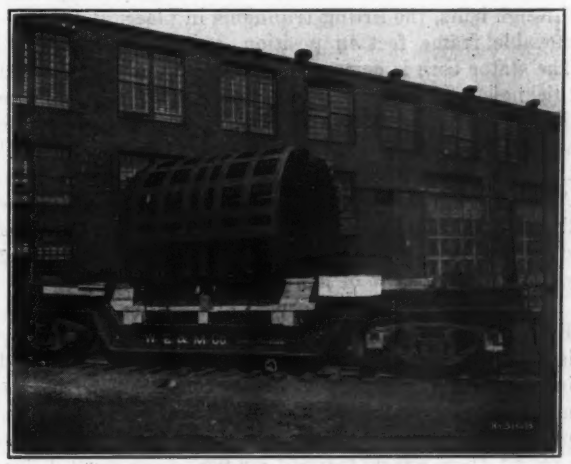


FIG. 1. GENERATOR STATOR LOADED ON DEPRESSED TYPE CAR, READY FOR BOXING

The stator frame is split in two sections at right angles to the axis of the rotor. Each half is a complete annular casting bolted to the other to form the frame. The complete frame is skeletonized as much as permissible, so that it acts as a guide and support for the stator laminations only. Lifting of the complete stator is accomplished by means of trunnions which are removed when the sheet steel superstructure is built in place.

In order to make railway clearances as great as possible, the feet on which the stator rests on the customers' foundations are made removable. The skeletonized

*Power Engineering Dept., Westinghouse Electric & Mfg. Co.

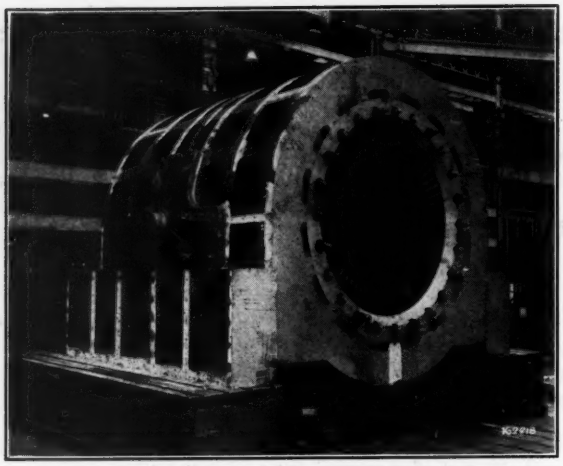


FIG. 2. SKELETONIZED STATOR FRAME

frame with the stator laminations held by temporary through bolts, the lifting trunnions in place, and the removable frame feet in position, are shown in Fig. 2. The stator core is composed of laminations of the usual thickness. These laminations are held in place by the double means of dovetails slotted in ribs cast in the stator frame and by compression under end plates pulled tight by the required number of insulated through bolts. After the stator laminations are built, but before the through bolts are pulled up to the necessary stress, the stator core is thoroughly sprayed with an insulating varnish with a view of maintaining the core tight.

Stator windings are formed of diamond type coils. Every individual strand of these formed coils is insulated with mica tape and the completed coil is incased in a mica folium wrapper pressed and wrapped by the micarta process. After the coils have been vacuum impregnated with insulating gum repeatedly and finish pressed, there are no trapped air pockets or weak dielectric spots. By the terms of the contract specifications, the completed winding was given a potential test of 35,000 v. for one minute. The end turns are of the involute form.

In order to equalize generated voltages and reduce eddy current loss in the copper, the strands of each coil

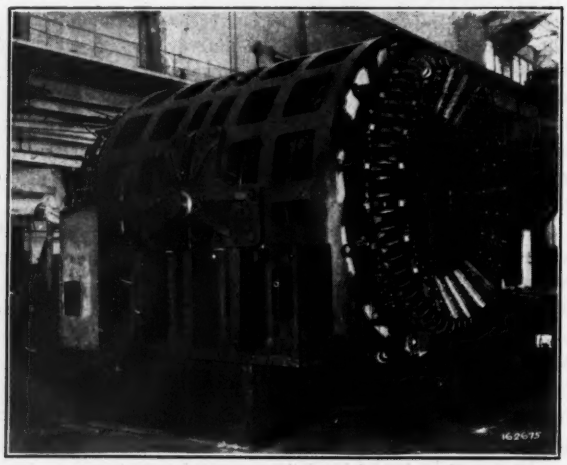


FIG. 3. STATOR WITH WINDING IN PLACE

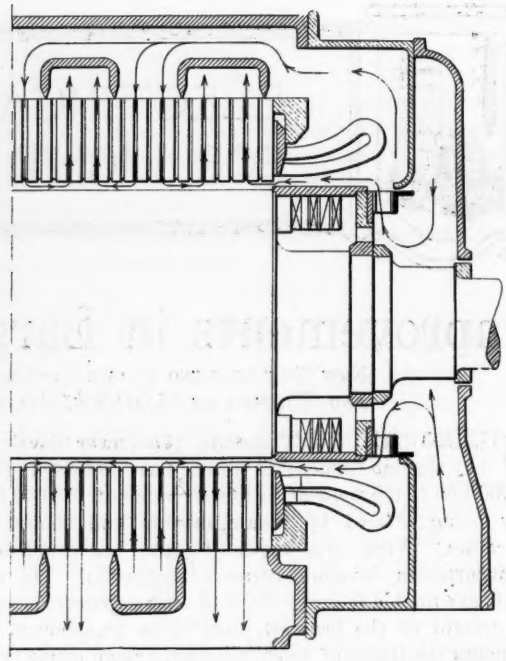


FIG. 4. MULTIPLE PATH RADIAL TURBINE GENERATOR VENTILATION

are transposed both depthwise and widthwise in successive slots, so that the strands in any phase group have occupied all possible positions in width and in depth in the slot by the time the phase group is traversed. A complete system of coil supports and blocking is used with a view of supporting the end windings against the forces set up by any short circuit that may occur and at the same time allow free access of cooling air to all parts of the end windings in which losses occur. A view of the stator wound in the shop is shown in Fig. 3.

In turbine generators, stress considerations and space limitations cause the losses to be concentrated in smaller space than the losses in lower speed generators. For that reason, it is necessary that the means of dissipating these losses from the small space in which they are generated be made most effective. A modification of the much older system of radial ventilation, known as the multiple path radial system, was applied to this generator, as shown in Fig. 4. In the simple radial system, all the air for cooling purposes is forced to enter from

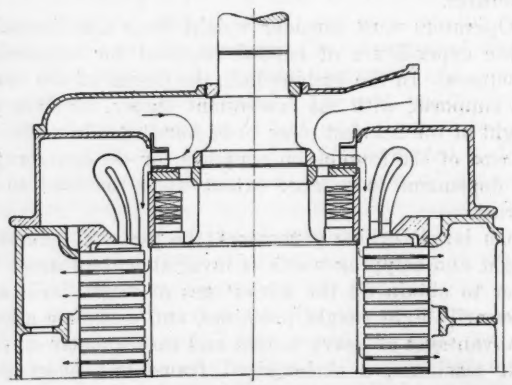


FIG. 5. SIMPLE RADIAL TURBINE GENERATOR VENTILATION

the ends of the machine and travel axially in the air gap and then pass radially through the vent ducts between packages of stator laminations to cored passages in the back of the frame, as shown in Fig. 5. The multiple path radial system of ventilation differs from the simple radial system in that air is forced by pressure built up by the internal fans to flow across the back of the packages of stator laminations axially and through the vent spaces between packages of stator laminations radially, in order to reach the air gap. In the air gap, the air moves along the rotor body and the stator tooth dips axially in order to reach the radial outlet vent ducts between packages of stator laminations. The heated air from the radial vent spaces is discharged to the sheet steel air outlet passages formed on the outside of the frame.

A closed circulation system of ventilation is used in which the cooling air is recirculated through the generator by means of internal shaft fans and cooled by means of water tube coolers. Between the air cooler element and the generator, a series of baffles are placed. These baffles are for the purpose of preventing any water from a cracked tube or leaking joint from squirting into the generator stator through the discharge air opening. A closed circulation ventilating system of this type is a positive aid in keeping the generator clean, because it uses the same air in a repetitive cycle and is an excellent means of reducing the fire hazard, because the small amount of air and consequently oxygen, contained in the system can support only limited combustion provided the circulation system is made reasonably leak-proof.

Stabilizing Long Distance Transmission Systems

Particulars of a New Scheme that Greatly Enlarges the Field of Long Distance Power Transmission

IF POWER could be generated with equal ease and cheapness at any place in the country and in any, even very small, volume, there would be no question of power transmission. Each consumer would then have his own power plant. It so happens, however, that some places are far more suitable for generating power than others. Water falls are not met with where convenience in power transmission would require them to be, but where nature has placed them, making necessary the use of transmission lines between the point of generation and the point of consumption. Depending upon economic considerations, it is found profitable in many cases to produce power at points from 200 to 300 mi. from the point of consumption. While transmission of large blocks of power over long distances is economically possible by using high voltage current, the increased length of transmission lines and the increased voltages gave prominence to certain factors which could not be neglected in the former small systems. The most serious of these problems is the question of stability of the transmission system.

If additional load is suddenly applied to the shaft of a large synchronous motor at the receiving end of the system, the input into the prime mover due to the sluggishness of the governor cannot increase at the same instant and the temporary deficiency will be supplied by the stored kinetic energy of the rotating masses of the motors and the generators. They will be retarded and the frequency of the system will decrease together with changes of voltage and currents all over the system until after three or four seconds the governor adjusts the input into the prime mover to correspond to the new load conditions and by accelerating the turbo-generator brings the frequency back to normal and establishes the angular position of the rotors corresponding to the new output of the generator.

The synchronous generators at the sending end and the synchronous machines at the receiving end may transmit the electric energy and convert it into mechanical energy on the shaft only if they are in synchronism, that is, if they are operating in step.

If as a result of some disturbance as, for instance, a flash-over, a phase-to-phase short circuit, switching out a part of the circuit or loss of a large percentage of generating capacity, synchronism is lost, the system cannot transmit any power and it becomes unstable and inoperative. In other words, the system is not stable for those conditions of operation.

Reactive Effects Limit Operation of Systems

When alternating current is flowing through a conductor, it produces along the conductor a magnetic field which, in turn, produces in the conductor a back electro-motive force which is known as reactance voltage drop in the conductor. The electromagnetic energy stored in this field during one half of the cycle is returned to the circuit during the second half of the same cycle and therefore sustaining this alternating field does not require energy. But it requires a magnetizing current which lags 90 deg. behind the applied electro-motive force and which is called lagging reactive current. Increase of this current in the system increases the lagging component of current in the stators of synchronous machines and the resulting armature reaction tends to increase the air gap flux and correspondingly, the terminal voltage. The amount of power, however, that can be transmitted over a certain system is proportional to the square of the voltage, therefore a voltage drop means a decrease in the power that can be transmitted and eventual loss of synchronism in the system. If a fault to ground or a phase to phase short circuit occurs, a current which is decidedly lagging results and if we do not want the generators to supply it to the system and thereby drop their terminal voltage, we must provide some sources on the system for supplying this reactance current and thereby maintaining the voltage all along the system. The means for this purpose in the system designed by Frank E. Baum are synchronous condensers distributed along the transmission line which supply reactance current at each point commensurate with the requirements of the system at a given moment. To be effective, synchronous condensers must be supplied with automatic voltage regulators and quick response exciting systems so that in case of a disturbance the voltage regulating equipment responds in a fraction of a second.

On the other hand, if the load is suddenly dropped, the capacity of the straight line, that is, its charging current, will produce excessively high voltages in the system. Again, in this case, the synchronous condensers distributed along the line by quick readjustment of their excitation, will limit the excessive voltages.

TRANSMISSION LINE COMPARED TO PIPE CARRYING WATER

Substantially the electric transmission line operates qualitatively in ways similar to a pipe carrying water under considerable pressure. The main difference between the two lies in the fact that the velocity of propagation of electric waves in a transmission line is in the order of 150,000 mi. per sec. Because of this, any readjustment in the line takes place at an enormously faster rate in the case of electric flow than in the case of water flow.

Assume now that water is being sent through a pipe from which a number of branches are tapped, some of them open, some of them closed. Assume next, that one of these branches of comparatively large size which has been closed is opened. It is obvious that pressure in the pipe will drop just as it does in an electric transmission line during a fall to ground. Suppose, however, that at certain points in this pipe line large reservoirs are connected to the pipe line and that when the large branch line is opened, valves in all the side reservoirs are also opened and thus cover the deficiency of water delivery by the main pump at the sending end of the pipe line. It is obvious that in this way the pressure in the line will be sustained. Again, assume that this large branch is suddenly closed. Valves into the reservoir then open and the normal pressure will be maintained. The opening and the closing of the valves to produce the best effect must be as quick as possible. It is comparatively easy to visualize how stable conditions would be re-established in such a water line and to all practical purposes this is substantially what is effected by Baum's synchronous condensers with quick response excitation—the arrangement being equivalent to the reservoirs described above. Synchronous condensers formerly were used at the receiving end of the transmission system for power factor correction and for voltage regulation at the center of the load and such condensers must be regarded as part of the load. Synchronous condensers as proposed by Mr. Baum and distributed along a long distance transmission line must be regarded as part of the line, changing the characteristics of the line in the direction favorable for the transmission of energy.

With this system the reactance of the line is substantially eliminated and the transmission losses are limited to resistance and leakage losses only. By providing the relatively short sections connected in series the line inherently possesses stable characteristics under all operating conditions and, while the voltage is maintained substantially constant, the difference in the power factor between the generating and the receiving end is materially reduced over that obtainable in previous systems. If this principle could be incorporated in a national power system, it would be possible to make the best use of the potential power sources of the country. Such a system would derive advantage from the time differences or shifts in daylight hours between the East and the West by reason of the difference in time of the peak loads on the system. The application of the Baum principle considerably enlarges the field of long distance transmission of electric power. By permitting more power to be transmitted over the same circuits or the same power over a longer distance, it opens for economic development new sources of power.—Mechanical Engineering.

Test Shows Relation Between "Pull" and Current in Solenoid*

MEASUREMENTS TAKEN AT GENERAL ELECTRIC CO. SHOW HOW FORCE EXERTED BY SOLENOID VARIES WITH CURRENT

MOST TEXTBOOKS and handbooks do not show definitely the relation between the pull on a plunger in a short solenoid and the current in its windings. Some formulas and approximate relations that are given indicate that the force on a soft-iron plunger in a solenoid, where there is no other iron in the field, is nearly a linear function of the current in the winding.

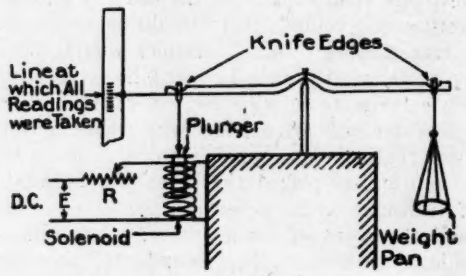


FIG. 1. DIAGRAM OF THE APPARATUS USED IN MEASURING THE PULL EXERTED BY CURRENT FLOWING IN A SOLENOID

On the other hand, it would appear, from the fact that the flux density at any point on the surface of the plunger is directly proportional to the current, and the force at any point is directly proportional to the square of the flux density, that, neglecting saturation, the force on the plunger should be directly proportional to the square of the current.

Differences of opinion have thus arisen as to what really is the true relation between the current in the solenoid and the force on the plunger. In order to settle the point, a test was made in which actual measurements were taken of the force and current. The solenoid used in the set-up was a standard voltage-regulator coil which was 3½ in. long and 2 in. mean diameter, wound on a brass spool having brass brackets for mounting. There was practically no iron in the field of the coil other than the one-half inch plunger which is standard for the particular coil used.

The set-up, as shown in Fig. 1, consisted essentially of a gravity balance. In order that the apparatus should be as sensitive as possible, all mechanical contacts of the balance were made knife edges.

All current readings were taken with the plunger at exactly the same place in the solenoid. The balance or force readings were taken from both directions on the scale to insure accuracy. Figure 2 shows graphically

*From an article by W. E. Lynch in the General Electric Review.

the relation found between force and current and between the square root of force and the current as derived mathematically from the force curve.

The graph in Fig. 2 shows a straight-line variation between the square root of force and the current. Hence, the square root of force varies directly with the current therefore, the force on the plunger varies directly as the square of the current.

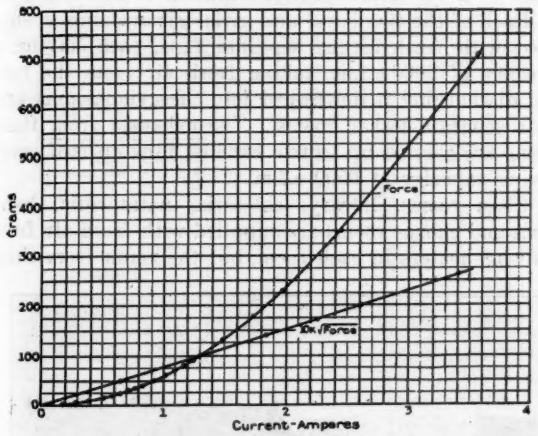


FIG. 2. CURVES SHOWING RELATIONS OF THE PULL ON A SOLENOID PLUNGER TO THE CURRENT PRODUCING IT

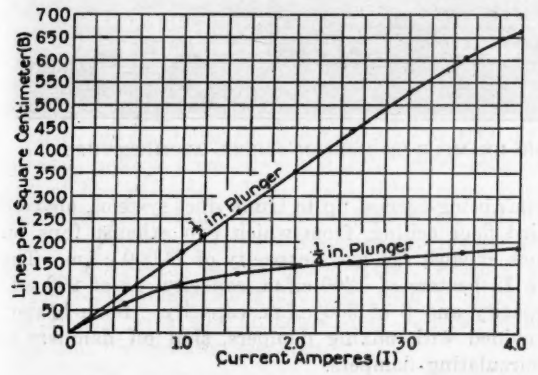


FIG. 3. SATURATION CURVES FOR PLUNGERS OF DIFFERENT SIZES. THE DEGREE OF SATURATION HAS A MARKED INFLUENCE UPON THE RELATION OF PULL TO THE EXCITING CURRENT

Since, when saturation exists, the flux density is not proportional to the current, the pull will not be proportional to the square of the current. It would seem, therefore, that saturation did not exist in the foregoing test. In order to verify this conclusion the saturation curves shown in Fig. 3 were taken on two plungers of different sizes, the upper curve being that for the plunger used in the test to determine the pull exerted by the coil. The bend at the upper end of this curve indicates the beginning of saturation, but this takes place far above the normal operating current value for the coil.

In Fig. 3 the lower curve was taken with a plunger one-half the diameter of the test plunger. This saturation curve shows well what is to be expected from using too small a plunger in a solenoid. In accordance with test, and as would be deduced from theoretical considerations, plungers of appreciable length compared to the length of the solenoid and those which are quite small in area compared to the cross-sectional area of the solenoid exhibit only a relatively small change in force for a change in current, due to saturation. It should also be borne in mind that plungers of extremely long solenoids of small diameter are particularly susceptible to saturation and its accompanying influence upon the pull that the plunger exerts.

It was, therefore, concluded that for any position of the plunger, in those cases where saturation does not exist, the pull will be proportional to the square of the current; but in any particular case, it would be advisable to determine by test whether saturation exists.

How One Company Works Out Its Future Development Plans

"THE DEVELOPMENT of our distribution system requires careful study and planning to keep the plant in proper condition and to provide for future loads," states Thomas Sproule, General Superintendent of Electric Distribution, Public Service Corporation. "One of the phases of the Distribution Department work is to forecast future loads in determining the extent of the development required. To facilitate the greatest possible degree of accuracy, forecasts are made for lighting, industrial power, and railway loads. Curves are prepared showing past loads in all substation areas, as well as for the entire territory. By carefully analyzing their various components, it is possible to project these curves for future years. This analysis includes consideration of the effect of increase in population on lighting load, and the change in consumption per capita we are experiencing. The industrial load fluctuates in a manner comparable to the business cycle, while railway load for the past few years is approximately constant.

"The Distribution Department is represented on the Load Development Committee which prepares a detailed forecast of load for the year, for the five years to follow, and for ten years in advance. This Committee combines the opinion of the Generation Department, the New Business Department, and the Distribution Department. Particular consideration must be given to large customers which the Commercial Department expects will come in our lines, so that facilities for service may be provided.

"In planning developments to keep pace with the increase in loads, it is necessary from time to time to provide additional transmission capacity to substations and to relieve substations of distribution circuit load when they have reached their capacity.

"Transmission relief has been provided through the increase in operating voltage and through the construction of additional lines. Inasmuch as the individual transmission line is but a unit in an interconnected transmission system, the installation of any new line must be considered with respect to its effect on the entire system, as well as with regard to the individual substation which it feeds.

"A construction budget is prepared annually, covering the cost of all necessary additions to the transmission, substation and distribution plant. An average expenditure of $15,000,000 each year has been required over the last few years to keep up with the development of the load and to improve operating conditions."

Heating and Ventilating a Large High School

UNIT HEATERS AND VENTILATING EQUIPMENT, UNDER COMPLETE THERMOSTATIC CONTROL IN CONJUNCTION WITH STEAM RADIATORS SUPPLIED FROM MODERN BOILER PLANT, MAINTAIN PROPER TEMPERATURES AND FRESH AIR IN NEW CLEVELAND HEIGHTS HIGH SCHOOL

ONE OF THE LARGEST and best designed school buildings in the state of Ohio is the new Cleveland Heights High School at Cleveland, Ohio. Heating and ventilating equipment for this building presents several novel features, which will be discussed in this article.

This building, shown in Fig. 1, has total cubic contents of 2,600,000 cu. ft., divided into 54 general class rooms, general offices, doctor's office, rest rooms, library, cafeteria, band room, chorus room, kitchen and serving rooms, natatorium, boys and girls club rooms, boys and girls special exercise rooms, woodworking room, boys' and girls' gymnasiums with showers and locker rooms, auditorium and stage gymnasium.

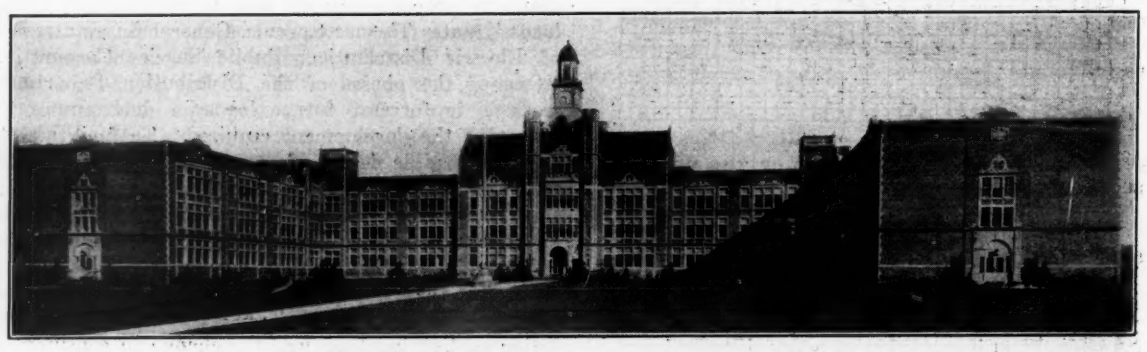


FIG. 1. CLEVELAND HEIGHTS HIGH SCHOOL IS A SPLENDID EXAMPLE OF MODERN SCHOOL ARCHITECTURE

The auditorium has a seating capacity of 2000 and, by using the stage, 2500 can easily be seated. An interesting feature of this stage is that it is large enough to contain a standard basketball court. Games can thus be played on the stage while the spectators occupy comfortable seats in the auditorium.

Several separate ventilating systems are provided for various parts of the building. Heating is by direct radiation in class rooms and various special rooms. In the class rooms an interesting dual control arrangement, using both Univent heaters and radiators, maintains healthful conditions with good economy, as will be explained later.

SEPARATE VENTILATING SYSTEMS

The ventilating system for the auditorium includes two 16,500-c.f.m. multi-blade supply fans and one 20,000-c.f.m. exhaust fan. Fresh air, taken from the roof through a large air shaft, is carried down to space below stage; here it passes through the two supply fans, Fig. 2, with their respective units of Vento heaters and discharges into air tunnels passing beneath the auditorium floor. Heated air is admitted into the auditorium through Knowles adjustable mushrooms beneath the seats. Exhaust air is taken out through ceiling grilles worked into the beam construction, also through grilles under the balcony ceiling. Grilles under the balcony ceiling have automatic dampers, controlled by a special thermostat that will open them if the air under the balcony becomes too hot. Provision has been made by automatic air-controlled dampers for recirculating the air in the auditorium to cut the cost of heating this space to a minimum when ventilation is not required.

Each of the two boys' and girls' gymnasiums is supplied with fresh air by separate fans, each having a capacity of 9000-c.f.m., taking fresh air from the roof and discharging it downward into the gymnasiums and their separate locker rooms. The exhausts from these rooms are carried up to two exhaust fans on roof, each having capacity of 6500 c.f.m.

Class rooms, library, cafeteria, natatorium, band room and chorus rooms are supplied with fresh air from Univent heaters in each room, but the vents from these rooms being carried up to trunk duct systems, above the third floor ceiling, from which two exhaust fans pull. Each exhaust fan has a capacity of 24,000 c.f.m. There are 12 heaters of 1200 c.f.m. capacity, 43 of 900 c.f.m. capacity and 8 of 500 c.f.m. capacity. Each heater is provided with mixing dampers, shut off dampers and recirculating dampers.

UNIT HEATERS AND RADIATORS UNDER CONTROL OF TWO THERMOSTATS

These Univent heaters in each room together with the radiators are under the control of two thermostats, one controlling the mixing dampers in the heater cabinets, the other controlling the steam valve on the radiator. In the smaller rooms, one heater is installed without a radiator adjacent to it. In some of the larger rooms, such as the combination cafeteria and study hall shown in Fig. 3, there are several heaters and several radiators. Their operation is as follows:

The thermostat controlling the mixing dampers of the heater is set to keep the room temperature within one degree of the 70-deg. limit of the thermostat. If a sudden change occurs in the outside temperature (as it frequently does in the lake cities) causing the temperature to drop to 68 deg. or lower, the second thermostat begins to supply steam to the radiator to keep the temperature up to 70 deg. The latter thermostat is intermediate in its action, opening the radiator valve gradually and thus avoiding overheating of the room.

As a further control on the Univent heater, if the

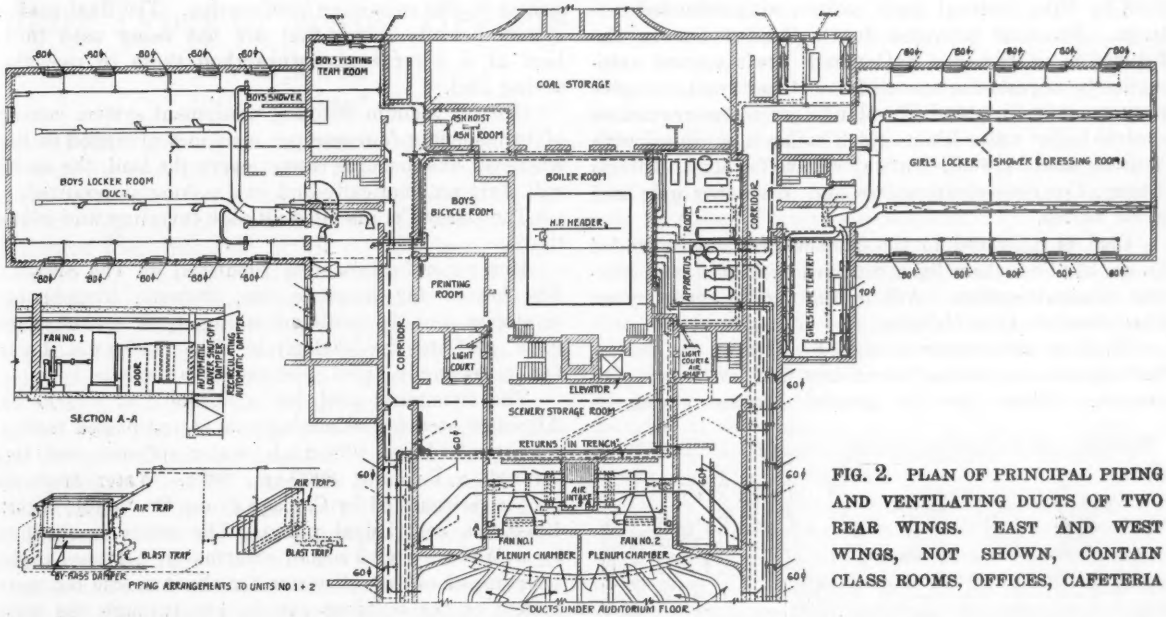


FIG. 2. PLAN OF PRINCIPAL PIPING AND VENTILATING DUCTS OF TWO REAR WINGS. EAST AND WEST WINGS, NOT SHOWN, CONTAIN CLASS ROOMS, OFFICES, CAFETERIA

temperature should drop to 60 deg. for any reason—such as insufficient steam—the fresh air damper will automatically close and the recirculating dampers will open. Thus the room air will be recirculated to bring up the temperature quickly to 65 deg., and then the action of the dampers is reversed. This scheme also reduces fuel consumption when heating up the cold building in the morning.

There are two toilet exhaust fans each of 1800 c.f.m. capacity, pulling from boys and girls toilet room sections of the building. The woodworking room is provided with an exhaust blower of 4300 c.f.m. piped to the various machines and discharging shavings and sawdust to a collector in the boiler room. Kitchen and serving room quarters are provided with a 5000-c.f.m. exhaust fan with special hoods over ranges, counter tables and dishwashing machine.

All fans were supplied by Buffalo Forge Co., driven by General Electric Co. motors. All the heaters were furnished by the Herman Nelson Corp.

Well-Equipped Boiler Plant Supplies Steam

For supplying steam to the above heating and ventilating system, a well-equipped boiler plant is installed. All electric power is purchased.

Total combined equivalent load in direct radiation is equal to 95,166 sq. ft. divided as follows: direct column radiators, 21,565 sq. ft.; unit heaters 22,980 sq. ft.; Vento for auditorium and two gymnasium supplies 28,120 sq. ft.; one 3000-gal. domestic water heater, 10,500 sq. ft.; one 6000-gal. swimming pool heater, 12,000 sq. ft.

Steam for these is generated at 60 lb. pressure in two 240-hp. Casey-Hedges vertical, bent-tube boilers,

FIG. 3. ONE SIDE OF COMBINATION CAFETERIA AND STUDY HALL, SHOWING ARRANGEMENT OF UNIVENT HEATERS AND RADIATORS FOR CO-ORDINATED OPERATION UNDER THERMOSTATIC CONTROL

fired by Riley natural draft stokers with extended settings. Space is provided for a third boiler in the future, as in Fig. 4. McDonough draft control automatically adjusts the speed of the stoker engine to give proper combustion and Cleveland feed water regulators control boiler water level. Each boiler is equipped with Vulcan soot blowers, Yarway blowoff valves, Illinois Engrg. Co. non-return valves and Walworth gate and globe valves.

Coal is delivered to the bunker over the extended fronts of the stokers by a Shepard coal hoist and electric monorail system. Ash is removed to grade by an Otis sidewalk type elevator.

High pressure steam is used for kitchen equipment, bathing suit dryers and sterilizers and hot water generators. Steam for the general heating system is

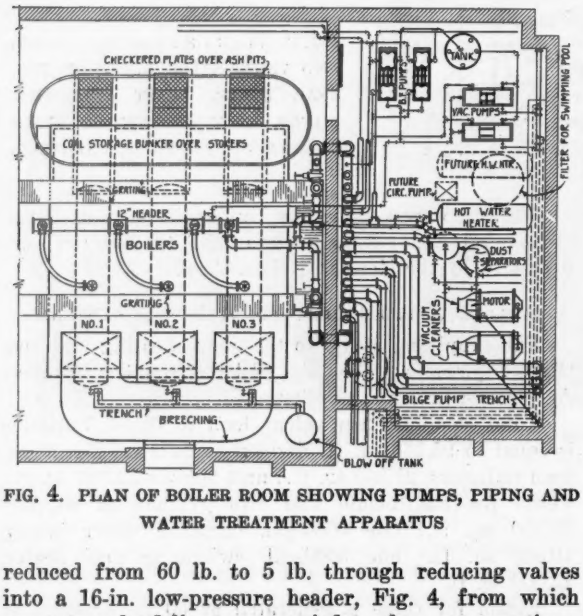


FIG. 4. PLAN OF BOILER ROOM SHOWING PUMPS, PIPING AND WATER TREATMENT APPARATUS

reduced from 60 lb. to 5 lb. through reducing valves into a 16-in. low-pressure header, Fig. 4, from which separate valved lines are carried to class room sections, general offices, auditorium, gymnasiums and swimming pool section.

The return system is of the vacuum type with Bishop & Babcock thermostatic traps in all radiators, unit heaters and drips and Squires heavy duty blast traps on all Vento stacks. Returns are brought back to a return header in the pump room, to which are connected two 10 by 12 by 12-in. Union vacuum pumps, arranged so that either or both can be used. Each pump is controlled by vacuum regulators. The vacuum pump discharges to a storage receiver with auxiliary cold water feed for makeup water.

The 10-by-7-by-12-in. duplex Worthington boiler feed pumps take the water from the storage receiver and discharge it to the boilers through a Griscom-Russell feed-water filter. Each boiler feed pump is controlled by a Fisher excess pressure regulator. Each boiler has an auxiliary water feeding system through a Penberthy water injector.

The dual system of heat control was installed by Johnson Service Co. with four separate divisions from a central distributing panel; one system to the school class room section, one system to the auditorium, one system to boys' and girls' gymnasium section and one system to the swimming pool section. The dual control system permits rooms that are not being used to be kept at a lower temperature than those in use, thus saving fuel.

Central vacuum cleaning equipment system consists of two Spencer four-sweeper machines arranged so that whenever one machine cannot carry the load, the second will start automatically and run as long as required.

The Carey Co. installed all pipe coverings and insulation.

Hot water heaters were furnished by The Sims Co. The heater for domestic use, showers, kitchen and lavatories is of the multi-coil storage type, capacity 3000 g.p.h. and storage 1000 g.p.h. The 6000-g.p.h. heater for the swimming pool is of the instantaneous type.

The swimming pool has a capacity of 60,000 gal. All water used for swimming pool is first passed through a Paige & Jones 6000-g.p.h. water softener and then through a Permutit 8000-gal. filter. Water from the pool is recirculated by Chicago Pump Co. double suction 125-g.p.m. centrifugal pump. The water is sterilized by a Wallace and Tiernan chlorinator. Bypass piping is arranged so that all water for the domestic hot water system of the building can be put through the water softeners if desired.

Cleveland Heights High School was designed by Warner & McCornack, architects, with Mayer & Valentine as consulting mechanical engineers. T. M. Shand Co. was heating contractor for the building. Edward Smith is chief operating engineer.

Lighting Cold Pulverized Coal Burners

ABOUT a year ago the Board of Education of Mason City, Ia., installed a Unipulvo unit pulverizer under a small 150-hp. straight tube boiler. Up to this time hand firing had been used. When the change was made, no water walls were installed in the new furnace; the old grates were simply taken out and the brick work changed so as to give a maximum combustion space. The entire length of the first rows of tubes was placed in the first pass of the boiler.

Each night the boiler is shut down and fired up again in the morning. During the night the setting cools off so that it is difficult to light the fire in the morning. When the installation was first put in service, the fireman started it up each morning by building a large wood fire but chief engineer, Fred Tims, discovered that this was a considerable waste of time and effort and developed a much better method.

Sawdust, shavings and small pieces of wood from the manual training shop are sent direct to the power house to be burned. Each day the fireman takes a large pasteboard carton or wooden box measuring 2.5 or 3 ft. along each side and fills it with sawdust and shavings. In the morning this is saturated with kerosene, set in the furnace, 4 to 6 ft. from the front wall and ignited. This heats the furnace up sufficiently so that coal from the burner will ignite when the unit pulverizer is started. They have been using this method for several months and find it to be entirely satisfactory.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, 285 Madison Ave., New York, will hold its 5th Annual Convention from October 25 to Oct. 29 next at the Carolina Hotel, Pinehurst, N. C.

Many Types of Water Heaters Available

By O. E. Frank*

IN ORDER properly to design a hot water heater for a given capacity and have it operate successfully and economically, the following factors should be considered: Whether the water is to flow through the tubes or around them, diameter of the tubes, velocity of the water in the tubes, allowable pressure drop on water side of heater, drainage of heater, elimination of air in steam spaces. There are, of course, other factors, such as the conductivity of the tube metal used, but it is considered by all designers that copper and brass are the most suitable materials for this service.

Hot water heaters for the power plant are classified into two general classes, closed and open. Open heaters have trays to break up the water into streams so that steam comes in direct contact with the water and gives up its heat. These are used generally for low pressure feed water heating. They are not of the tubular type.

Closed heaters of the tubular type are further divided into two types, storage and instantaneous. Storage heaters are always of the steam tube type, that is, the steam is in the tubes and the water to be heated is around the tubes. They provide a large space for storing hot water so a supply is available for peak load. Tubes of either copper or brass through which steam is passed are contained in the bottom of the tank to heat the water. The water circulates in the tank by gravity when none is being drawn by the system. The tubes in the storage tank are usually 1¼ to 1½ in. in diameter because there is nothing to be gained in using smaller diameter tubes, and also because of the fact that smaller tubes of any appreciable length soon fill with water in the discharge end and the friction of the water makes necessary higher initial steam pressure.

Instantaneous heaters are either of the steam tube type or water tube type, although the latter form is the most generally used. In this type no storage capacity is provided, and the water is heated as fast as it is drawn. The heat is in the shell around the tubes and condensing gives up its heat.

Type of Heater Should Be Selected with Care

In choosing the type of heater to be used, due consideration must be given to the available steam supply. Instantaneous heaters require steam only when water is being drawn, therefore its demand for hot water is intermittent and a steam supply plus the total demand must be available at all times in order to insure proper functioning of the heater. Exhaust steam from steam driven machines can be used if the demand for water does not exceed the steam supply available, but generally speaking, when exhaust steam is to be utilized for heating water for which the demand is not steady, it is better to use the storage type.

In calculating the heating surface for storage heaters, the water velocity is not taken into consideration and the rate of heat transfer generally used is 250 B.t.u. per hr. per sq. ft. per deg. temperature difference. The area of the heater is calculated by dividing the product of the pounds of water to be heated and the temperature rise by the product of the coefficient of heat transfer and the mean temperature difference between the steam and water. In calculating instantaneous steam type heater areas, the same method of calculation is used and about the same rate of heat transfer may be used, unless the shell is of such design that an appreciable velocity may be obtained, in which case the velocity must be considered.

In an instantaneous water tube type heater, the coefficient of heat transfer varies with the velocity of water in the tubes. The coefficient of heat transfer that can be safely used in this case is 360 times the square root of the velocity. This value covers the slight scaling of tubes which is found under ordinary conditions. If the heater is kept absolutely clean the heat transfer can be taken as 400 times the square root of the velocity.

Large Trap Should Be Selected for Drainage

To obtain good efficiency from a hot water heater the steam space must be relieved of air and the condensate quickly removed by a trap of adequate capacity. Choice of a trap should be made on the basis of pounds of water it will handle and not on the size of the trap. It is well to have the trap twice the capacity required in order to take care of peak load, as most heaters are designed with a large overload capacity.

In selecting the trap, consideration must be given to the fact that the steam pressure in the heater seldom reaches an appreciable pressure above atmosphere due to rapid condensation of the steam. In fact, unless a vacuum breaker is installed, the pressure frequently is below atmosphere so that, except in special cases, the trap must be selected to have its required capacity at atmospheric pressure.

*President, O. E. Frank Heater & Engineering Co., Buffalo, N. Y. Abstract of paper presented before the A. S. H. & V. E. meeting.

Protective Coatings for Boiler Drums

That a protective coating is quite effective in retarding or preventing corrosion in boiler drums, is indicated in replies to an investigation conducted by the N. E. L. A. Great stress is generally laid on the fact that the surfaces must be thoroughly cleaned before application of protective coating. In this connection one company states that the drums are first well cleaned with wire brushes and hand scraped to remove the softer scale. If any hard scale remains it is chipped off with a small air hammer, care being taken not to roughen the plate. Another company reports that it operates new boilers 60 days to loosen the mill scale, after which the surfaces are cleaned to a point where the metal shines.

When applied to a surface not thoroughly cleaned, the coating will not adhere for any length of time. One company reports that a protective coating applied on drums of a new boiler over a factory coat of red paint disappeared in two months.

None of the companies reported having used protective coatings on boiler tubes. The reason for this, as given by one company, is that they did not believe the tubes could be cleaned thoroughly enough for the coating to stick.

Being right on the job all the time is the safest way to keep it.

Conowingo Units Under Construction

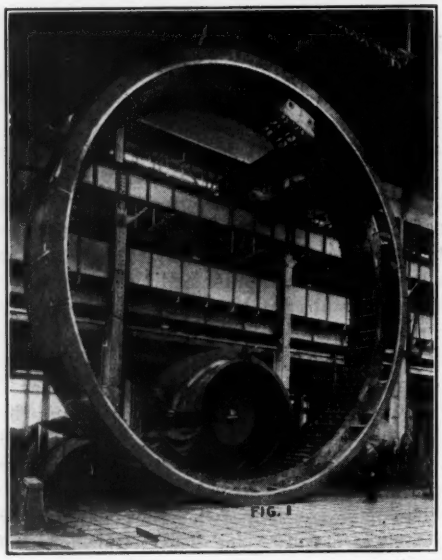


FIG. 1

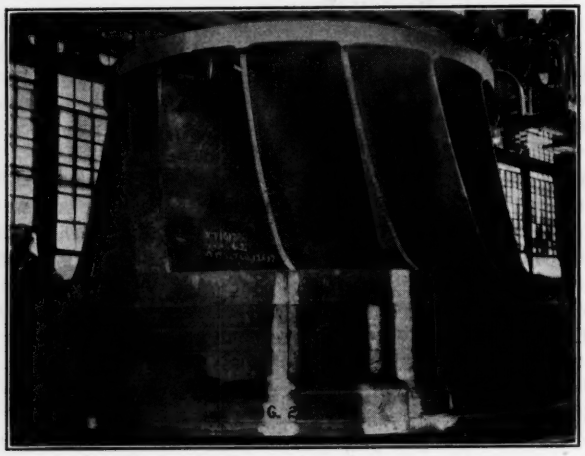


FIG. 2

THE CONOWINGO hydroelectric development on the Susquehanna River is rapidly nearing completion. Work on this great development was started on March 8, 1926, and it is expected that the first units will be ready for operation by July, 1928. The initial installation will consist of 7 vertical shaft water wheels each rated at 54,000 hp.

An idea of the enormous size of these units may be gained from the photographs on this page. In Fig. 1 is shown the stator frame for one of the 40,000-kw. generators standing on end in the shops of the General Electric Co. This is of the welded plate type and is approximately 40 ft. in diameter. It required 2000 ft. of welding in its fabrication.

In Fig. 2 is shown a view of a partially assembled runner for one of the water wheels built by the Allis-Chalmers Co. This is the largest runner ever built, the total weight being in excess of 200,000 lb. It is built in three pieces and is designed for 60,000 hp. under a maximum head of 97 ft. Extreme outside diameter is 200 inches. This runner is approximately 50 per cent larger in capacity than the largest runner ever built previously for an equivalent head. The 30-in. test model of this runner broke all previous Holyoke tests for efficiency, obtaining 93.34 per cent efficiency.

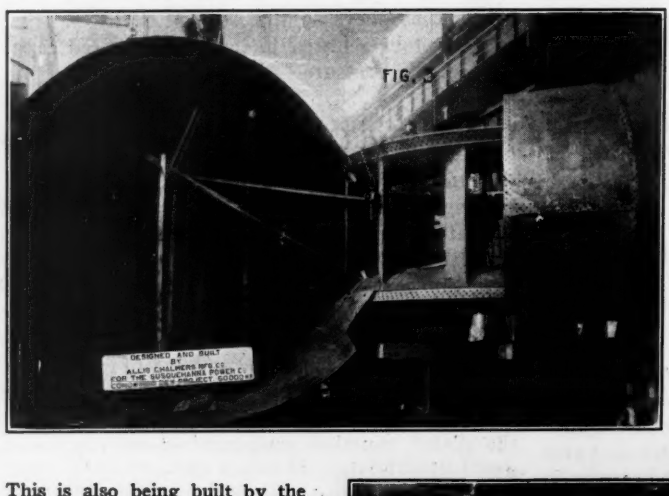


FIG. 3

A detailed view of one of the steel plate spiral casings and cast steel speed ring for the turbines is shown in a partially assembled condition in Fig. 3. This is also being built by the Allis-Chalmers Co. The casing inlet diameter is 27 ft. 2 in., the overall width 65 ft.

Figure 4 shows a large lower bearing bracket for one of the generators built by the Westinghouse Electric and Manufacturing Co. This bracket weighs 16,000 lb., and is 24.9 ft. in diameter and is built up of 24-in. standard girders. All joints are arc welded. The opening for the shaft at the center is 68 in. This is one of the heaviest examples of welding of this sort and indicates the confidence the builders feel as a result of their experience with the process.

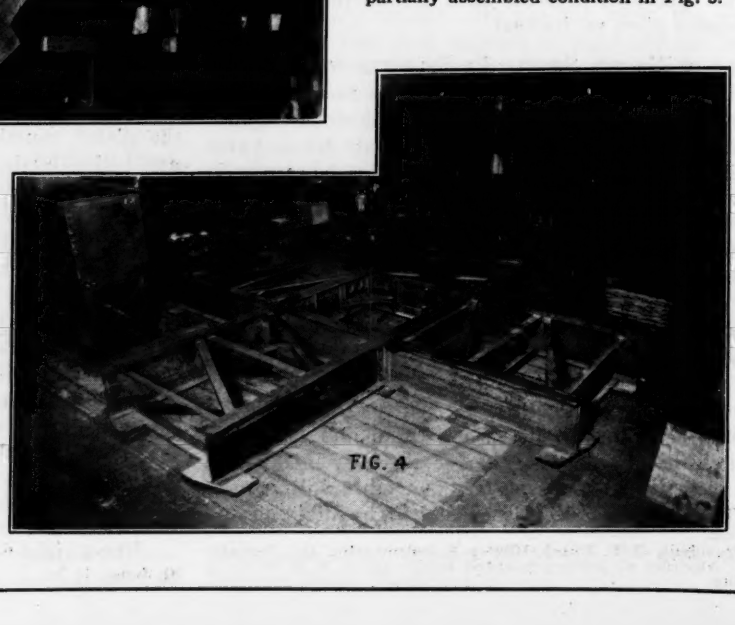


FIG. 4

Check Valve Permits Speeding Up of Pump

NEAR CALAMA, in Northern Chili, a stream which travels underground for some distance appears at the surface, and a little way farther it disappears again. At the time of which I write, a copper reduction plant was being installed at Chiquicamata, and as water was a very scarce commodity in that part of the world, it was decided to install a pumping plant where the stream

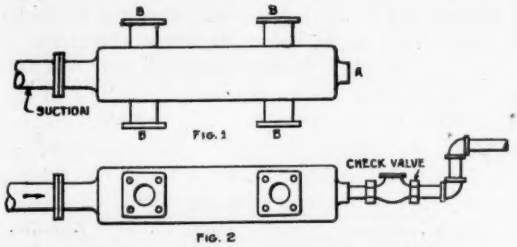


FIG. 1. PLAN OF SUCTION MANIFOLD
FIG. 2. ELEVATION SHOWING CHECK VALVE AS INSTALLED
B.B.B.B. PUMP CYLINDER CONNECTIONS

came to the surface, and pump water from there to the copper plant, 14 mi. away.

Installation of a Snow 10 and 2 by 10-in. duplex outside packed ram pump and an upright boiler was made; coal being hauled by mule wagon from Calama. For more than half the distance from the pump, 4 in. in diameter extra strong galvanized pipe was used and 4-in. standard for the remainder of the way. The suction line was 4-in. pipe with a horizontal run of about 40 ft., and a drop into the pool of about 6 ft.

On starting the pump, it was found that if the speed of the pump exceeded 120 strokes per min., there would be ram slip and considerable jar, the pumping pressure being over 900 lb. per sq. in. The slip was attributed to the pump cylinders not being completely filled with water when the discharge strokes commenced. There were also heavy pulsations in the suction line.

It was suggested that an air cushion chamber be placed on the discharge manifold, but it was not clear how this would help the slippage, and to cushion the discharge strokes it would be necessary to provide an air charger of some kind—not a simple matter with so high a pressure. It was decided that by placing a cushion chamber on the suction manifold, some good would result, and one was installed as shown at A, Fig. 1.

It was the rule, when starting up the pump, to allow it to discharge through a free outlet until all air had been exhausted, then the discharge was gradually turned into the main line through a check valve. Even with the cushion chamber on the suction line, the pulsations continued and occasionally slugs of air seemed to find their way from the cushion chamber to the pump. These would cause so much shock as to suggest possibility of wrecking the pump.

Studying the matter further, it appeared that if the suction flow could be made continuous, the pump could be speeded up without causing slippage. On removing the cushion chamber and placing the hand over the opening so as to act as a non-return valve, allowing air and water to escape but no air to reenter, the pump was made to operate quite smoothly at 240 strokes per min. At the same time there was a strong and almost steady stream of water shooting past my hand. The ball check valve and seal was therefore substituted for my hand as shown in Fig. 2 and all pump trouble disappeared.

It seemed unnatural to have water shooting out of the suction of a pump placed 6 ft. above its source of supply, but this was doubtless a case of velocity and pressure.

Long Beach, Calif. E. J. JORDAN.

Boiler Washing

AN ENGINEER in charge of a h.t. boiler which required frequent washing out, found himself seriously hampered by having to use cold water and consequently to allow a long cooling period before it was safe to inject it, the entire process requiring nearly 24 hr.

Determined to overcome his difficulty, the engineer investigated methods used for that purpose. One consisted of large fittings similar to injectors, using steam from another boiler and delivering water, which had been received under pressure, to the boilers in a warmed condition.

Another used a regular boiler feed injector, the steam lines being so piped that any boiler of a battery of three could be washed out while steam from any other boiler could be used in the injector for warming the water.

Boiler washing was done in a third case by means of an ejector made of various sizes of pipe and fittings in such a manner that the steam supply was blown through a smaller and centrally located pipe into a combining pipe. This was so arranged that the water supply passed around the steam supply pipe for a distance of several inches, creating a suction which drew water from an adjacent pond.

In a small plant that had only one boiler, a 1000-gal. steel water tank was used as a storage tank. A centrifugal pump was so piped that it could draw water either from a pond or from the storage tank and in the latter case add its pressure to that due to gravity. Just

before closing down the boiler, preparatory to washing it out, the tank was partly filled with water from the pond, then a connection with the boiler blowoff was opened and hot water forced into the tank until it was full of water at 212 deg.

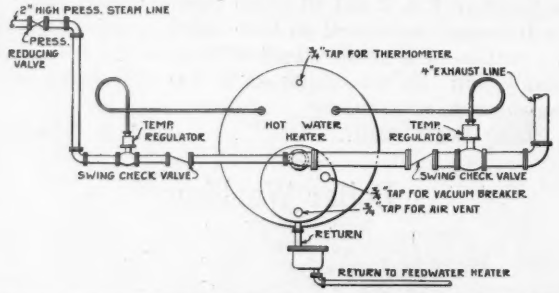
As a result of these investigations the engineer set up a 1000-gal. open tank about 10 ft. above the floor in his boiler room. A coal burning tank heater was connected to the tank and a centrifugal pump used to fill the tank also for adding force to the water during the washing out process. The feed water piping was so connected that water could be sent to the boiler either through or around the exhaust steam heater.

By this means, hot water was made available by burning a small amount of coal in the tank heater and the 10 ft. head enabled the pump to deliver this hot water without trouble to the boiler. Furthermore, the already heated water could be pushed through the exhaust heater in order to be still further heated.

Indianapolis, Ind. JAMES F. HOBART.

Hot-Water System at Denver Hospital Insures Uniform Temperature

CONSTANT TEMPERATURE and automatic action which reduces to a minimum attendance requirements is secured by the unique hot-water system installed at the



PIPING ARRANGEMENT INSURES AUTOMATIC ACTION AND PROVIDES FOR BOTH HIGH AND LOW-PRESSURE SERVICE

Denver General Hospital. The heater consists of a 940-gal. Patterson Kelley cylindrical combined heating and storage tank 48 in. diameter by 120 in. long. This has a heating capacity sufficient to heat 2500 gal. of water per hour from 40 to 180 deg. F.

Exhaust steam controlled by a Powers automatic control valve is piped from the engine room on the low-pressure side through a 4-in. line. On the high-pressure side a 2-in. line runs directly from the boilers. In this latter line a Mason pressure reducing valve and a Fulton automatic control valve set 10 deg. F. lower than the Powers control valve in the exhaust line are installed. The tank is also equipped with a Trane air vent and the vacuum breaker is a Jenkins swing check valve and Swartwout 1¼-in. steam trap.

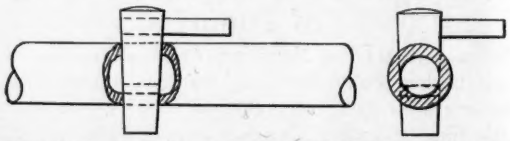
During the summer months there is ample exhaust steam to take care of all hot water requirements and the high-pressure line is shut off entirely. But during the winter there is not sufficient exhaust steam at all times. When the demand warrants, therefore, the high-pressure line automatically cuts in.

This system, which was designed and installed by the writer to fulfill the specific requirements of a hospital, may at first glance, appear to be too elaborate but when it is realized that hot water in a hospital is a prime necessity every hour of the twenty-four, any reasonable expense to attain this service would seem to be well worth while.

Denver, Colo. H. J. BROWN.

Taper Pin Makes Useful Plug for Stop Valve

OFTEN A STOP or valve is needed in an oil pipe line made of brass or copper tubing. Such a stop valve can be made easily and quickly by drilling a hole



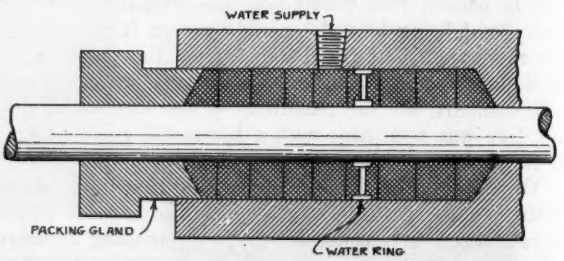
TAPERED PIN, FITTED IN PIPE LINE FORMS STOP VALVE WHICH MAY BE CLOSED BY TURNING IT 90 DEGREES

through the tubing in the desired location. This hole is then reamed with a taper reamer of suitable size, so that a taper pin when inserted will close the bore of the tube entirely. A ⅛-in. hole is drilled in the pin so that the lower edge of the hole coincides with the lower inside edge of the tubing. A short piece of ⅛-in. cold rolled steel is fitted in the large end of the taper pin for a handle. A one-quarter turn of the taper pin will shut off the flow of oil. The surplus length of the taper pin is cut off after it has been properly seated.

Syracuse, N. Y. H. L. WHEELER.

Tight Packing Gland Cuts Off Water Supply

IN STARTING a new centrifugal pump of the multi-stage type, considerable leakage occurred at the packing glands. To lessen the leakage the packing was tightened, although not too strongly, and soon the shaft



LACK OF SUFFICIENT PACKING BEHIND WATER RING CAUSES IT TO BE CUT OFF FROM ITS COOLING SUPPLY

heated so badly that it became necessary to stop the pump, as releasing the glands did not help.

Taking the packing out we found that in tightening the packing, the gland-water rings had been pushed in far enough to have their water supply cut off.

To remedy this, sufficient packing was placed at the bottom to permit the water ring to be located just in front of the water supply pipe so that in tightening the packing the water supply would not be cut off from the ring. The best way was to remove the union from the feed pipe so as to permit the ring to be seen from the outside.

Clarkdale, Ariz. CHAS. LABBE.

Oil Engines in Industry

IN THE August 15 issue, J. W. Chadwick states as follows: "Oil engines would be in much more extensive use in the ordinary run of industries except for the very strenuous opposition put up by the central stations who have power to sell."

Before making any further comments on the foregoing, the writer would like to say that he is an enthusiast on oil engines of the Diesel type and had experiences with them in the early days of their application to stationary work. On account of this experience, in almost every plant with which I have been connected the question of the use of oil power has been considered.

In going into the various objections to installing an oil engine, it does not seem as if the central station needs to put up much of an argument in the case of a plant under 100 hp. since the care of motors is much simpler than that of the engine with its storage tanks, cooling system and various other parts that need skilled attention. If the plant in question can use large quantities of low pressure steam in manufacturing, there is not much argument as to which kind of power should be installed.

About 3 yr. ago the question of additional equipment for a steam plant of about 400 kw. capacity came up. It was planned to remove the oldest unit of 100 kw. capacity and install in its place a 500-kw. unit which would be of the uniflow type and arranged to run condensing during the non-heating season. Very little steam was required for process work. The construction problems were simple, the principal one being the laying of a long pipe line to bring condensing water from the river. The total expense was to be $40,000.

Figures from one of the prominent oil-engine manufacturers were obtained, price quoted being $52,000 for a 520-hp. engine alone. If the expense of the generator, oil tanks, changes to roof, which was too low for a vertical unit, and various other accessories had been added, the total price would have been about $65,000. It is hard to see how anyone could honestly recommend such an installation as this. Supposing that the oil equipment had been installed, the man who had been in charge of the steam plant for 20 yr. would not have been capable of maintaining it in a satisfactory manner so that it is probable that the labor item would have increased considerably.

In another instance with which the writer was intimately connected, a concern decided on the advice of their master mechanic to generate all of their power with oil engines. Their power equipment consisted of two steam plants and two oil plants, all of which they wished to centralize under one roof. They used considerable process steam all of the year and a large amount during the heating season so that it was necessary to run a boiler room all of the time. Having installed 900 kw. of oil-driven units, they did not understand that some attention should be given to the maintenance and repairs and that a fairly high grade of help should be employed, so it was natural that they should run into difficulties to the extent that steam equipment had to be purchased to help out on the load.

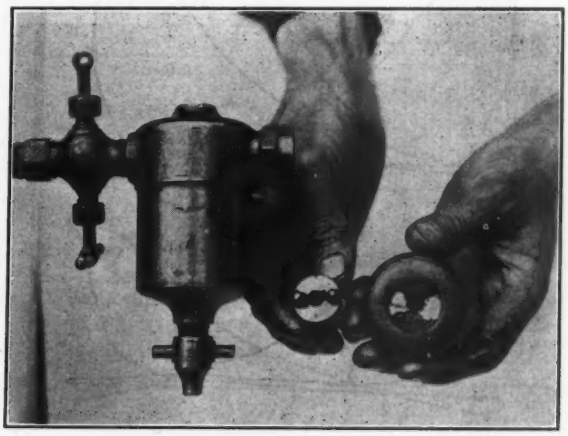
This plant with its large demand for steam at times should have been originally designed as a mixed proposition with either bleeder turbines or engines to use when steam for heating or process work was needed. The oil engines could then have carried the excess load. The final result was that the oil equipment with the generators which had been installed at an approximate cost of $150,000 were sold for little over the junk value.

For marine work the oil engine seems to be unexcelled within its limits and also for much stationary work but the prospective users must be educated on what to look for in care and maintenance and also in the fact that over-enthusiasm in their installation may cause difficulties in procuring fuel in a not distant future.

Cambridge, Mass. G. H. KIMBALL.

Tinfoil Repairs Wooden Handles of Valve Stems

WOODEN VALVE STEM handles have only one drawback. If they are not tightened a bit frequently, the wood wears badly where the lugs of the stem bottom enter and hold it.



ENLARGED HOLES DUE TO WEAR, WHEN FILLED WITH TINFOIL, FORM SNUG FIT

A quick and practical way to fill the holes in such a case is to tightly roll the tinfoil taken from a cigarette or tobacco package into a small, hard ball, just a bit smaller than the enlarged holes in the wood of the handle. Tap the stem bottom into place, following it up with the holding screw. The lugs on the stem will be held by the filling as good as by the wood in a new handle. Repaired in this way wooden handles stay snug and tight a long time.

Missouri Valley, Iowa. FRANK BENTLEY.

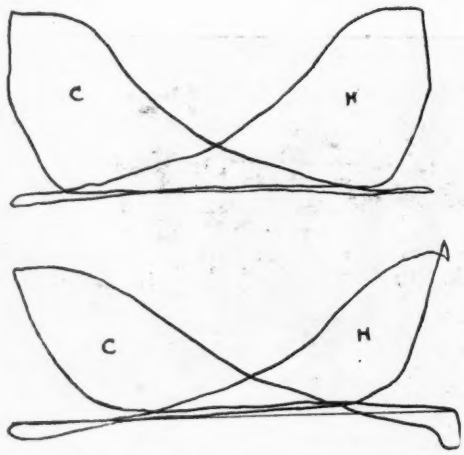
DUE TO THE EVENT of large turbine units for high pressures making necessary the use of joint bolts of over 2 in. in diameter, which cannot easily be tightened with certainty that the bolt is not overstressed on one hand or insufficiently stressed on the other, all large bolts and the important smaller ones employed in rotor structures by one manufacturer have holes provided throughout their longitudinal axis to provide a means of measuring the stress of the bolt when drawn up. In this way the amount of tightening necessary to produce a definite joint pressure and bolt stress may be accurately determined.

QUESTIONS AND ANSWERS

Loose Piston Rings Cause Knocking

ENCLOSED please find two indicator cards taken from our 22 and 44 by 27-in. cross compound Buckeye engine. We carry 150 lb. steam and 30 lb. receiver pressure. We run non-condensing and at present at no pressure above atmosphere.

Our low pressure cylinder has a bad slap at the end of its downward stroke when any load is carried: When



KNOCKING NOT INDICATED IN DIAGRAMS TAKEN FROM ENGINE. LOOPS SHOWN IN LIGHT LOAD DIAGRAM DUE TO HIGH EXPANSION RATIO

running very light, the slapping disappears. How may we overcome this slapping action? R. E. G.

A. Slapping, such as referred to, may be reduced by increasing the lead if the slap is in the high pressure side or decreasing the lead if it is in the low pressure side but no valve adjustments will correct the trouble, which is probably due to loose rings.

We note the loops in the cards. These are probably due to the large expansion ratio you are using while running non-condensing, the engine having been designed for condensing operation. The high pressure valves should have more lead and the low pressure valves slightly less. We believe that if you would considerably cut down your compression on the low pressure side, at least to a point where the loop, just before admission, is cut down, you might better your condition, as this has a tendency to reverse the pressure on the valves and lift them off their seat and in some cases cause a decided knock; however, the loops are not bad and heavier load will remove them. The loops may be caused by a tendency toward vacuum in the exhaust pipe caused possibly by quick admission of exhaust steam into a fairly large exhaust pipe.

Editor's note: Investigation of the piston rings in the above engine revealed the fact the piston rings were found to be extremely loose and the lower steam chest bushing so loose that it was held in place only by the keeper bolt. New rings were installed and bushing refitted, after which all slapping disappeared.

Quality of Steam in Steam Turbine Exhaust Obtained by Computation

HOW CAN I FIND the quality of the steam in the exhaust of the steam turbine so that I may know how much heat goes to the condenser? The Mollier diagram would be theoretically correct, but it is not correct from a practical standpoint because of reheating. How is this reheat factor determined? A. W.

A. The quality of steam in the exhaust of a steam turbine cannot be determined directly, but must be computed from the heat content of the entering steam, the radiation and bearing losses of the turbine, and efficiency of the generator and the electrical output. For a fairly large generator, the efficiency can be computed from the following equation:

$$\text{Eff.} = 0.98 - \frac{0.055}{\sqrt[3]{(\text{kw. rating} \div 1000)}} \times \frac{\text{rating}}{\text{load}}$$

and the mechanical losses, that is bearing friction, radiation losses and oil pump requirements, can be taken as equal to

$$\text{Per cent of normal rating} = \frac{40}{\sqrt{(\text{kw. rating} \div 1000)}}$$

This is in per cent of normal rating of the turbine and remains about constant regardless of the load.

Working backward from the electrical load carried and the heat in the entering steam, the amount of heat accounted for in electrical energy, generator and mechanical losses can be approximated and the amount of heat going to the condenser can be computed, obviously, as heat which passes the throttle and is not converted into useful work or friction losses, and must appear at the exhaust of the turbine and go to the condenser.

If by the Mollier diagram you mean theoretical adiabatic expansion, you are correct in your statement; but this expansion line is not correct. The error, however, lies not in reheating, but in the stage or nozzle efficiency of the turbine itself. Reheating tends to throw the expansion line closer to the theoretical.

In general it may be said that the efficiency of a turbine is 10 per cent higher in the superheated than in the saturated area. If, therefore, the steam consumption of the turbine at any point is known, the expansion line of the turbine through the entire area or range can

be plotted, first by locating the exhaust condition as computed from the steam consumption of the turbine and then by a cut and try method lay out two lines, one from the entering steam condition down to the saturation curve, the other line from the saturation curve to the exhaust condition. The slope of these two lines should be such that that portion lying in the superheated area would give a 10 per cent greater efficiency than that in the saturated area. Details regarding the calculation of these curves, generator efficiencies and losses are given in a paper by Brown and Drewry in the 1923 volume of the A. S. M. E. Transactions.

By accurate measurements, the expansion line of the turbine can be plotted on a Mollier chart and the heat content of the steam at various points in the expansion, obtained in this manner. These data may be obtained by tests at various extraction points in an extraction turbine or they can usually be plotted from data supplied by the manufacturer.

It is true that the internal losses in the first part of the turbine are reconverted into heat and partially utilized by the lower stages of the turbine; that is, the energy lost in friction and eddies in each stage goes at once into heat and is absorbed by the steam so that it is available as heat energy for partial recovery in all the following stages. For this reason, the summation of the available heat drop in the individual stages always exceeds the overall heat drop. The reheat factor is the ratio of the summation of heat drop in each stage to the overall heat drop and furthermore, since the average stage efficiency is computed relative to the summation while the turbine efficiency is computed relative to the overall heat drop, it follows that the ratio of turbine efficiency and stage efficiency is also the reheat factor.

This reheat factor depends not only on the initial and final steam conditions, but on the shape of the condition curve as well. That is, upon the relative efficiency through various stages. If the early stages show poor efficiency, the reheat factor will be slightly larger and the average stage efficiency slightly lower than in another turbine of the same efficiency in which the initial stages are relatively good. In modern multi stage turbines the condition of expansion and uniform stage efficiency is approximated.

Increase in Load Raises Boiler Water Level

DOES THE water level in a boiler change when the load is suddenly changed from 200 hp. to 500 hp. although the steam pressure remains constant? In our boiler, which is equipped with a Copes feed-water regulator, the water level in the water gage glass seems to rise under these conditions. What causes this?

G. C.

A. The greater number of steam bubbles going through the water during the sudden increase in rate cause the body of water to be momentarily expanded until equilibrium is again established when normal operation is assumed.

Another action, which has the effect of temporarily lowering the water level after the effect of the above momentary action has been dispelled, occurs where boilers are equipped with this type of feed-water regulator. This rise in water level, due to a sudden increase in load, prevents the sudden opening of the feed valve to meet the demand, resulting in a temporary lowering of the water level when a steady load is established, thus avoiding too sudden introduction of a large body of feed water which would not only suddenly reduce the steam production, but also suddenly cool off boiler parts tending to cause leakage and perhaps rupture.

Boiler Feeding Made More Effective by Rearrangements

I AM NOW pumping water back from our kiln, as shown in Fig. 1, into an open heater. What I want is something that works similar to a trap so that I can

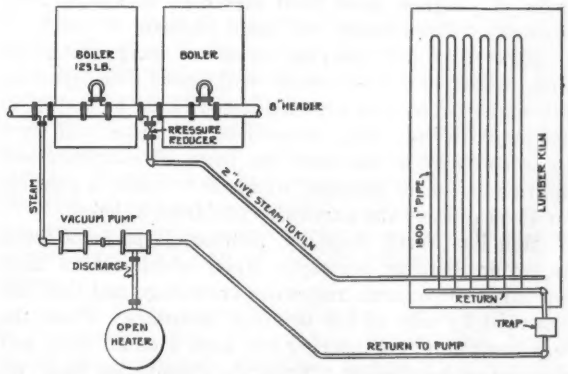


FIG. 1. ARRANGEMENT OF BOILERS, KILN, PUMP AND OPEN HEATER WHICH DOES NOT GIVE SATISFACTION

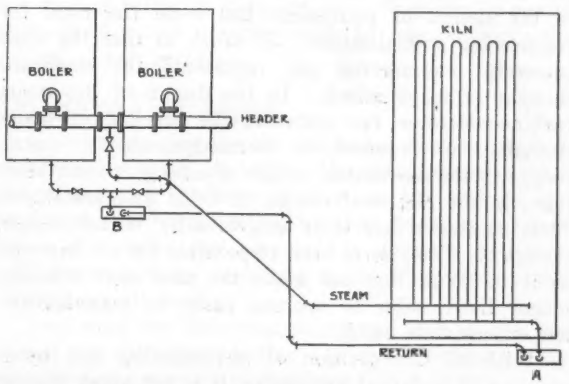


FIG. 2. ARRANGEMENT WITH RETURN TRAPS WHICH AVOIDS NECESSITY OF USING A PUMP OR OF PASSING RETURN THROUGH HEATER

pump into this and have the water return to the boiler by gravity or in some similar way. We carry 125 lb. pressure on the boiler. I want to do without running an extra pump.

F. K. D.

A. Why not use two return traps connected up as shown at A and B in Fig. 2? This arrangement would accomplish what you desire without the use of a pump and without passing the return water through a heater. For your conditions this arrangement will operate satisfactorily if the difference in level of the two traps is not more than 50 ft.

EDITORIAL COMMENT

Personalities in Engineering

As engineers whose thoughts are centered on the unvarying laws of physics and chemistry, we are prone to underestimate the value of the personalities that have brought our profession up to its present state of recognized indispensability in our present civilization. Many scientists whose discoveries have forged links in the chain of progress have lived and died in comparative obscurity. Even today, we have pioneers at work on problems that are delaying progress along particular lines, whose accomplishments will speed developments but whose names and personalities will not be known to the public. Only their immediate associates will have an opportunity to recognize the traits of character and the foundation of training which have made it possible for them to solve the particular problems in hand.

Men like Watt, Faraday, Newton, Hero have given us revolutionizing principles upon which others have worked improvements requiring knowledge and skill not possessed by any of the original inventors. From the very beginning, engineering has been a cumulative and cooperative profession. Scientific discoveries have resulted in industrial developments, further experiments and improved designs to meet the broadened demands and more exacting conditions. Along with refinements in the design of equipment has come the need for engineering specialization. So much so that the most successful engineering job represents the combined thought of many minds. In the design of the steam turbine-generator for instance, the services of many specialists are required—in thermodynamics; in metallurgy; in the mechanical design of casings, rotors, bearings; in the electrical design of fields and armatures. Thus engineers lose their individuality in the design, though they may have been responsible for an improvement in detail that has made the unit more efficient, longer lived, safer to operate, easier to manufacture, less expensive to build.

With all this division of responsibility and interweaving of technical knowledge, it is not much wonder that engineers lose sight of the individual but view with admiration his engineering accomplishments; that they give little thought to the character and motives, the years of training and self denial, the developed skill and technical knowledge, all of which have been necessary to the final noteworthy achievements.

Many other professions are individualistic for the reason that a person engaged in them performs an entire job. Thus we have prominent lawyers, physicians, lecturers, artists, authors, musicians, whose products are individualistic. Prominent engineers, however, are today almost invariably part of an organization and their work must co-ordinate with that of others in the production of a noteworthy engineering accomplishment. Notwithstanding this tendency of engineers to allow a man's work to overshadow his personality, one of the most enlightening sources of information on engineering developments is found in biographies of prominent engineers. Here we find the character-building experiences through which the engineer has passed. We find the motives urging him to think along the lines of his greatest accomplishments. We are led step by step through his process of reasoning and the development of his ideas. To know the steam ship, one should know Fitch and Fulton. Without an acquaintance with Franklin, Edison, Steinmetz, Westinghouse, the entire history of the electrical power industry would be an unromantic description of devices and mathematical formulas.

The engineering field is still full of interesting personalities and we should not allow our devotion to engineering facts, figures and formulas to blind us to the many fine characters who are today laying the foundations for future industries.

Public Ownership?

"Public Ownership" has always had an alluring sound to many persons who felt that Utopia would in some providential way be reached through its office.

Public ownership would no doubt succeed very well, if the public functioned in fact as owner but, as pointed out by Dr. Geo. L. Hoxie, Research Engineer for the Southern California Edison Co., in a paper presented at the meeting of the Pacific Coast Gas Association, when one says that he "owns" a property he means not merely that he paid for it but that he has some control over it. Dr. Hoxie contends that the public has no such control in the case of publicly owned utilities. He says "The taxpayers indeed pay the bills, but the politicians are the real owners who handle the properties as they wish, sometimes in defiance of the expressed will of the voters. Indeed the usual scheme does not permit voters to express themselves." An elected official selects politicians, generally without any pretense to ability in the particular line or, in fact, to ability in any other line than that of politics, to compose some public utility board; this board itself frequently acts as a mere rubber stamp for some political staff executive.

What is usually termed "Public Ownership," therefore, Dr. Hoxie says, should be more properly called "Political Ownership" and political ownership has always resulted in "autocratic" control. He calls attention to the "necessary change from democracy to autocracy that inevitably accompanies the entrance of democracy into large scale business enterprise." Speaking of the great loss experienced in governmental ownership in Ontario, Dr. Hoxie said "Financial losses, however, are unimportant. The vital thing is the domination of the government by its supposed creature."

Autocratic control permits the building up of strong political forces of "tax-eaters." George H. Roberts is quoted as saying in this connection: "Everywhere in Europe ownership of the railways is burdensome to the governments because they must be run at a loss in order to satisfy the public."

Citing our most important recent national phases of government-in-business, he mentions government operation of railroads during the war period which cost the taxpayer one billion six hundred million dollars, and government ownership and operation of ships, of which Secretary Hoover said in 1924, "We paid three billions of the taxpayers' money for a fleet—but we have written it down 90 per cent in 6 years to $300,000,000 and, if the accounts were based upon true costs with interest and depreciation, we should find that we are losing over one hundred million dollars of the taxpayers' money a year in operating it. Yet private shipping is earning profits. Nor is this the fault of the Shipping Board; it is inherent in the system."

The idea of political ownership, Dr. Hoxie indicates, is old. It is as old as recorded history. In referring to the many failures of government ownership, he said, "it is a curious thing that with all our intelligence we do not as a race seem to be able to read the lessons of history with profit. It seems unfortunately to be true that each generation must usually learn through its own experience."

Back of the failure of government ownership lie deep seated facts of human behavior which were as universal and fundamental before government ownership existed as they are today. These facts are based upon a few original instincts among which the most outstanding probably are desire for ownership, self preservation and desire for self-expression or "individuality," as it is commonly termed.

Desire for ownership, which is usually accompanied with desire for mastery, is strong but most persons forget that control involves much more than mere direction to perform. Control equally requires means for seeing that duties laid down are properly fulfilled. Herein is where the fallacy of public ownership lies. Self-preservation of the individual or self-betterment successfully combats desire for ownership of the scattered group. In time the office holder realizes that what is everybody's business is nobody's business and he naturally settles down into a slough of complacency toward the public and of selfish acquisition with regard to himself. Only under conditions similar to those with which big business is usually identified such as immediate supervision and control by a properly qualified individual reporting to a financially interested directing board, could success in government ownership be expected, but such conditions do not persist even if initially adopted in such organizations.

Referring to the trend from political ownership to private ownership which now exists and which has existed for some time, Dr. Hoxie said, "Instead of the few, small and insignificant enterprises, all government-owned, that were known in the old days of absolutism, we have today a multitude of important undertakings, great and small, all devoted to the service of humanity—with surely 99 per cent of them monuments to individualism."

Selling Refrigeration Service

Since the introduction of the electrically-operated domestic refrigerator, resulting in tremendous changes in the refrigeration business, we have been wondering why it was that the development of these units was not carried out long ago by the makers of refrigerating machinery themselves. It is now too late, however, to speculate on this point. The development is out of their hands and they can only follow the new trail as best they may.

This development has been a splendid thing for the entire refrigeration industry, we feel. It has thrown a searchlight on the field of refrigeration as a whole. It has aided the power utilities in leveling off their load curves and in keeping down power costs. It has created a new industry and provided a much needed stimulus in the artificial ice field.

Another angle to this situation has presented itself to us. There is at present a large potential market for both the electrical refrigerator and artificial ice. Why cannot the enterprising artificial ice manufacturer also arrange to handle some make of domestic electric refrigerator? In other words, let him sell not ice, not electric refrigerators, but refrigeration. Let him sell the idea of refrigeration, either by wire, by gas or by ice, according to the economic conditions of the various consumers, which will of course change from time to time.

As far as we know, this plan has not been tried up to the present time. There may be economic factors which will prevent it. It would do one thing, however. It would break down the feeling that the sale of electric refrigerators for the home and the sale of ice for the home are two antagonistic, competitive businesses. To our way of thinking, they are not. They are, it would seem, merely two separate parts of one business—the selling of refrigeration.

On Rare Occasions

Sometimes a peculiar feeling comes over us which is generated by some particular bit of information that makes us want to throw the hat on the back of the head, put our thumbs in our armpits, broaden our face into a real smile, put a twinkle in our eyes and then with a merry ha ha pronounce to the whole wide world "That's me all over."

Just read the following paragraph and if you too do not get that same feeling you don't belong to the blue blooded power plant family:

"The determination of industry's center is made on the capacity of steam engines, steam turbines, water wheels and internal combustion engines in the manufacturing plants and public utility power plants."

That comes from the U. S. Geological Survey in a report indicating the westward movements of the center of industry. Incidentally, in 1908 the center was placed 110 mi. east of Chicago on the northern boundary of Indiana and 10 yr. later it was located 60 mi. east of Chicago. In 1926 it was placed 50 mi. southeast of Chicago.

Of course, we in the family have always felt that power is the backbone and sinew of all industry but to have the Government publicly declare this to be the fact is a rare occasion and gives us a tendency to strut.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Speed Variation at Will

FOR OPERATING industrial machinery variation of speed is often essential and change of speed while running is desirable. High-speed, constant speed motors are economical to purchase, hence a mechanism

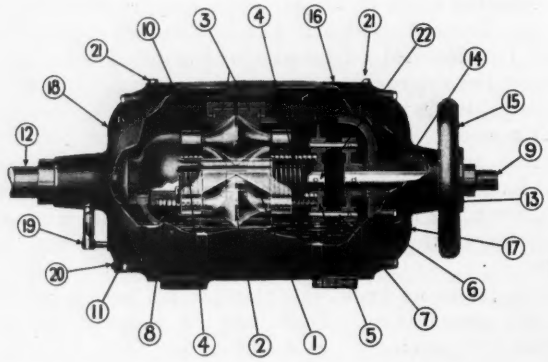


FIG. 1. CONSTRUCTION DETAILS OF JFS VARIABLE SPEED TRANSMISSION

which allows of their use and also permits of close regulation of the speed of driven machinery has a wide field of application.

Power is received by the JFS transmission at high speed and delivered at lower speeds either for direct connection to machinery or for still further speed reduction by belt, chain or gear transmission. Speed of the low-speed shaft can be varied over a 5 to 1 range and any intermediate speed secured, adjustment being made while all equipment is running. Rotation may be in either direction and application may be for increasing instead of reducing speed if desired.

To accomplish this a planetary roller bearing train is used, enclosed and running in oil, the unit pressures between surfaces being considerably lower than those ordinarily used in ball and roller bearing loadings. Figure 1 shows the details of construction and principles of operation.

High-speed shaft 9 receives the power and transmits it through a compensating coupling to center shaft 22, which also runs at high constant speed, carrying the inner races 1 secured to it by feather keys. These races slide along the shaft and are pressed toward each other by powerful springs, 4. They engage three planetary rollers, 2, which also bear on outer races, 3, and are set in revolution by the inner races, 1. The rollers, by their bearing on the outer races, are caused to revolve about the shaft, this motion being carried through yokes, 10, to the spider, 11, which is rigidly keyed to slow-speed shaft 12. The left-hand half of race 3 is fixed to the casing; the right-hand half is mounted on a movable housing 13 whose position is controlled by screw 14 and hand-wheel 15.

By turning the wheel so that the housing is moved to the left, races 3 are brought together and rollers 2 forced inward to the position shown. The rollers force inner races 1 apart against spring pressure, bringing the smallest diameter of the rollers into contact with the largest diameter of those races and largest diameter of the rollers into contact with largest diameter of outer races 3. This causes shaft 12 to revolve at the fastest available speed. By moving the housing to its extreme right hand position, races 3 are moved apart, rollers 2 are forced outward by the pressure of springs on the inner races 1, the smallest diameter of races 1

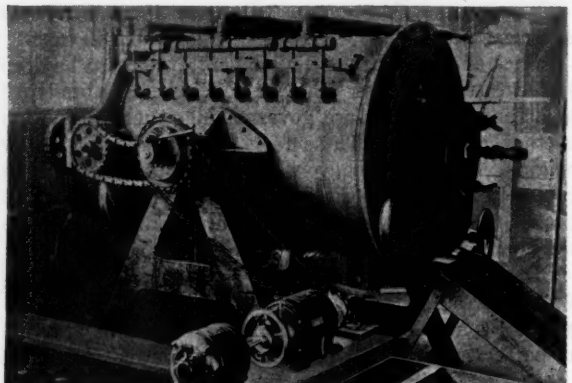


FIG. 2. ADAPTATION OF JFS TRANSMISSION TO DRIVING A CARBURIZING FURNACE AT VARIOUS SPEEDS

makes contact with the largest diameters of rollers and smallest diameter of rollers contacts with smallest diameter of races 3. This gives shaft 12 its slowest available speed. Intermediate positions of the housing 13 give intermediate speeds by any desired gradation, simply by turning wheel 15.

By applying power at constant speed to shaft 12, variable increased speed may be had from shaft 9.

These transmissions are built in four sizes to transmit from 1 to 15 hp. at the lowest speed of variable speed shaft and in two types. Type R has a maximum reduction of 8 to 1 with range of 5 to 1 as, for instance, from a 1200-r.p.m. motor speeds from 150 to 750 r.p.m. can be obtained. Type RG has maximum reduction of 40 to 1 so that from a 1200-r.p.m. motor speeds from 30 to 150 r.p.m. can be obtained.

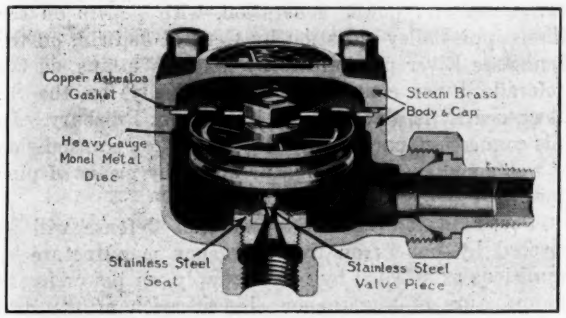
Figure 2 illustrates the application of JFS transmission from a motor to a sprocket-chain drive on a rotating furnace. The JFS variable speed transmission has been developed and is manufactured by Stephens-Adamson Mfg. Co. of Aurora, Ill.

Webster Series 78 Traps for Process Steam Pressures

FOR USE PRIMARILY in conjunction with industrial equipment using process steam at pressures between 10 lb. and 100 lb., the Webster Series 78 thermostatic trap has recently been placed on the market.

As shown herewith, the expansion member of the trap is of monel metal, heavily ribbed and held in position by a circular heavy brass plate fitting in a recess in the trap body. A distance nut separates the circular plate and the expansion member to permit free circulation of steam around the diaphragm. The cone-shaped stainless steel valve closes against a square-edged stainless steel seat with an expanded opening, set in a brass bushing screwed into the outlet.

Cover and body of the trap are of steam brass. These new traps are made by Warren, Webster & Co., Camden, N. J., in angle pattern only and in ½, ¾ and 1-in. sizes.


Copper Asbestos Gasket
Steam Brass Body & Cap
Heavy Gauge Monel Metal Disc
Stainless Steel Seat
Stainless Steel Valve Piece

SECTION THROUGH THE SERIES 78 THERMOSTATIC TRAP

Two pressure classes are furnished: No. 2 class for pressures up to 50 lb., and No. 3 class for pressures from 50 to 100 lb. While intended primarily for pressures above 10 lb., these traps will work equally well at lower pressures, although their capacity will decrease with the pressure.

The Webster Series 78 dirt strainer has been provided to be placed ahead of the Series 78 trap when located at a drip point in the supply piping or when attached to apparatus likely to contain core sand, pipe scale or sediment. Both products are described in detail in Bulletin 1200, just issued by the manufacturer.

New Crane Bucket Designed for High Speed

ADAPTABLE to practically any type of crane or shovel, the new Orton bucket for digging, excavating and handling material such as coal ash and cinder has been developed by the Orton Crane & Shovel Co. of Chicago, Ill. This new bucket is the result of 25 yr. experience in this field.

It is built with sufficient weight to bury itself in the material deep enough to collect a full bucket load, and has speed enough to insure three trips per minute. Case hardened renewable wearing blocks guard the cable and keep it from cutting the top of the bucket. Straight lead sheaves keep the cable in the bottom of the score, while flat braced back arms of extra heavy

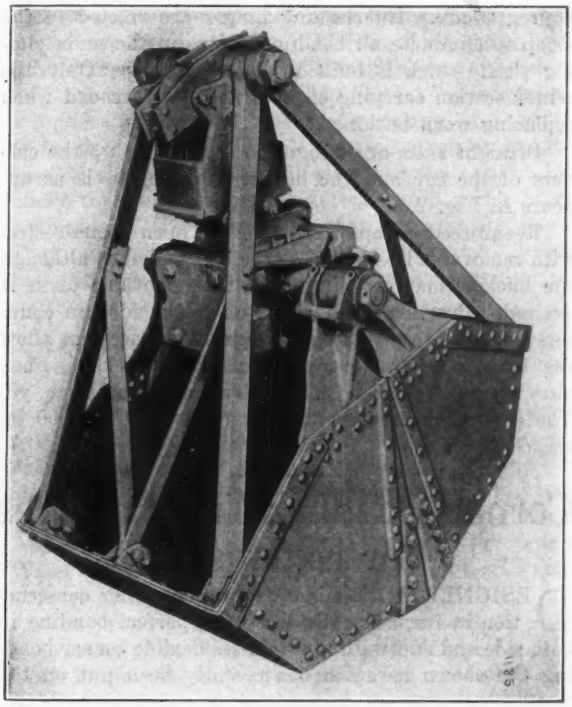


FIG. 1. A NEW TYPE BUCKET DESIGNED FOR QUICK EASY OPERATION AND RUGGED SERVICE

section are pinned at the top on both sides to prevent lateral distortion. Removable bronze bushings are used throughout with Alemite-Zerk fittings provided at all vital wearing points for injection of lubricants under

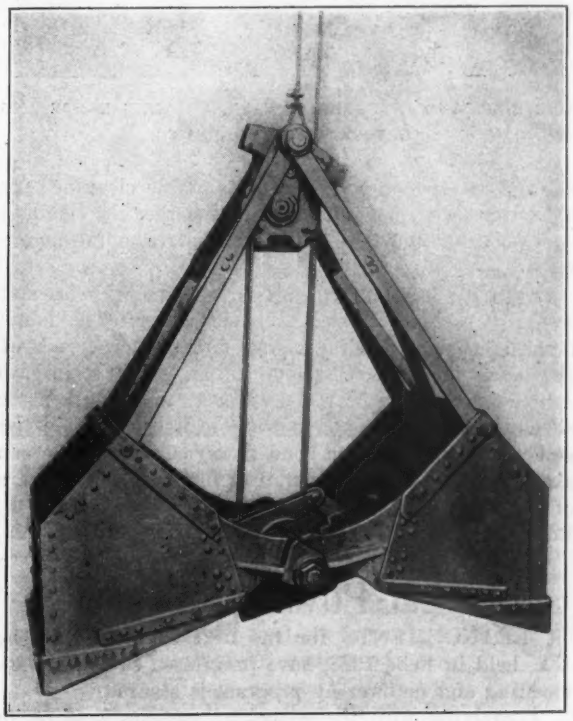


FIG. 2. THE STRAIGHT SIDES ARE OF A DECIDED ADVANTAGE WHEN UNLOADING CARS

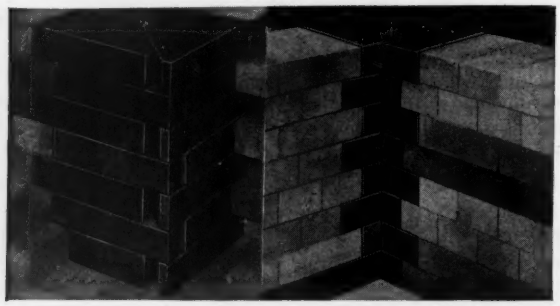
high pressure. Interlocking hinges are riveted to the scoop to eliminate all bending strains in the main closing shaft which is built in three sections. Only the center section carrying sheaves need be threaded when replacing worn bushings.

Straight sides are designed for cleaning up the corners of the car and the bucket, when open, is as appears in Fig. 2.

Reenforced scoops are made of open hearth steel with removable lips bolted to the digging edge, although the buckets may be equipped with removable teeth if desired. Practically all rivets on the inside are countersunk so as to give a smooth inside surface and allow the bucket to discharge the material quickly. Four sizes are built, ranging in capacity from 1 to 1½ cu. yd. The corresponding weight runs from 2300 to 4000 lb. respectively.

Corner Bonding Tile Provides for Expansion

DESIGNED TO eliminate faults of corner construction in furnace walls and effect perfect bonding in both side and end wall, the Reintjes flexible corner bonding tile shown herewith has recently been put on the



TILE INSTALLED IN FURNACE WALL, SHOWING INSIDE AND OUTSIDE VIEWS OF JOINT

market. It is intended to provide ample clearance for expansion at the corner and to tie together the side and end walls and prevent the front wall from falling inward.

Each tile is the thickness of one course of brick and serves as a starting brick for each course. The joints break at each succeeding course and form a corner of the inner nine-inch refractory lining. The tile in each course overlaps the next lower course, to strengthen the structure it is developed for use with brick set in the solid header or quarter bond patterns. These tile can also be placed in the side wall at intervals to take care of expansion. They are produced by George P. Reintjes Co., 2517-19 Jefferson St., Kansas City, Mo.

Midwest Power Conference

ARRANGEMENTS for the next conference, to be held in Feb., 1928, have progressed so that an interesting and noteworthy program is assured.

Complying with the wishes of societies wishing to have a part in the work of the conference, the committee has been increased so that nine societies now have a part in its work. These are American Institute of Electrical Engineers, American Institute of Mining Engineers, American Society of Civil Engineers, American Society of Heating and Ventilating Engineers, American Society of Mechanical Engineers, American Society of Refrigerating Engineers, National Electric Light Association, National Safety Council, Western Society of Engineers. The committee has organized, by the election of Major Rufus W. Putnam as chairman of the conference, A. D. Bailey as vice-chairman, K. A. Auty as treasurer and G. E. Pfisterer as secretary.

From Feb. 14 to 18 the conference will be in session, the program including addresses on Social Aspects of Power Development by W. F. Green, president of the American Federation of Labor, followed by a meeting with discussion of power applications to ventilation, refrigeration and cooling, power convenience in the home and domestic uses of gas heating.

One day will be given to the general topic of development of waterways for control of floods, irrigation, navigation and power generation, with papers on the Mississippi Valley situation by General Jadwin, on the Tennessee River possibilities by Major Watkins, on the Colorado River control by Colonel Kelly, on the St. Lawrence River development by Colonel Pillsbury. In this connection, papers will be presented on transmission of water and gas under high pressures by means of pipe lines.

Power in its relation to national defense will be covered by papers on the emergency manufacture of munitions as affected by power supply, on power in the manufacture of nitrates, on electrification of the steel industry and on the value of regional power surveys in the program of defense.

In a session on economics of power stations will be taken up stage heating of feed water, comparison of reheating of steam by live steam and by boilers, high-pressure operation and relation of capital costs to operating economy of a system.

Thursday afternoon will have an inspection trip to the new Sanitary District's filtration plant and, as an alternative, a symposium on the Development of transmission systems as related to continuity of service.

Further consideration will be given the economics of power stations at the Friday session, with papers on combustion control, on trends in steam generation, on characteristics of Fuels and on prevention of scale and corrosion.

It is expected that the conference meetings will be held at the new Stevens Hotel and that frequent bus transportation will be provided between the hotel and the Coliseum where the power show will be in operation.

Railroad Launches Power Plant Program

UNDER THE supervision of C. C. Chase, general supervisor of power plants, the Missouri, Kansas & Texas Railroad is carrying out an extensive power plant improvement program.

At Sedalia, a new boiler house with three 250-hp. O'Brien cross-drum boilers fired by Cokal Pulverzone stokers will supply steam at 175 lb. gage. The boilers will be set high with the breeching insulated with Sil-

o-Cel. All pipe joints are being welded. Ash will be handled by a steam jet and combustion controlled by a Defender damper regulator. Eight Republic flow meters will be installed in the plant, the other instruments being of the Brown recording type. Natural draft will be furnished by a 165-ft. concrete stack being built by the Boland Construction Co. of St. Louis. F. T. Tietze is chief engineer and plans to have the plant in operation by October 1. No power is generated in the plant, electricity being purchased from the City Light & Traction Co. of Sedalia.

At Denison, Texas, a tie-treating plant is under construction and here the power equipment will consist of two 250-hp. O'Brien cross-drum boilers, a Cochrane open feed-water heater, Cameron boiler feed pumps and Republic flow meters, in addition to the necessary vacuum pumps, creosote pumps and air condensers required in the tie-treating process. As before, all piping joints will be welded. This plant is expected to be in operation by December 1. Mr. Chase is in charge of installation and construction of both plants and, in addition, is supervising the resetting of two h.r.t. boilers in the company's boiler plant at Ft. Worth, Texas.

Two Units Increase Don Pedro Capacity to 42,000 Hp.

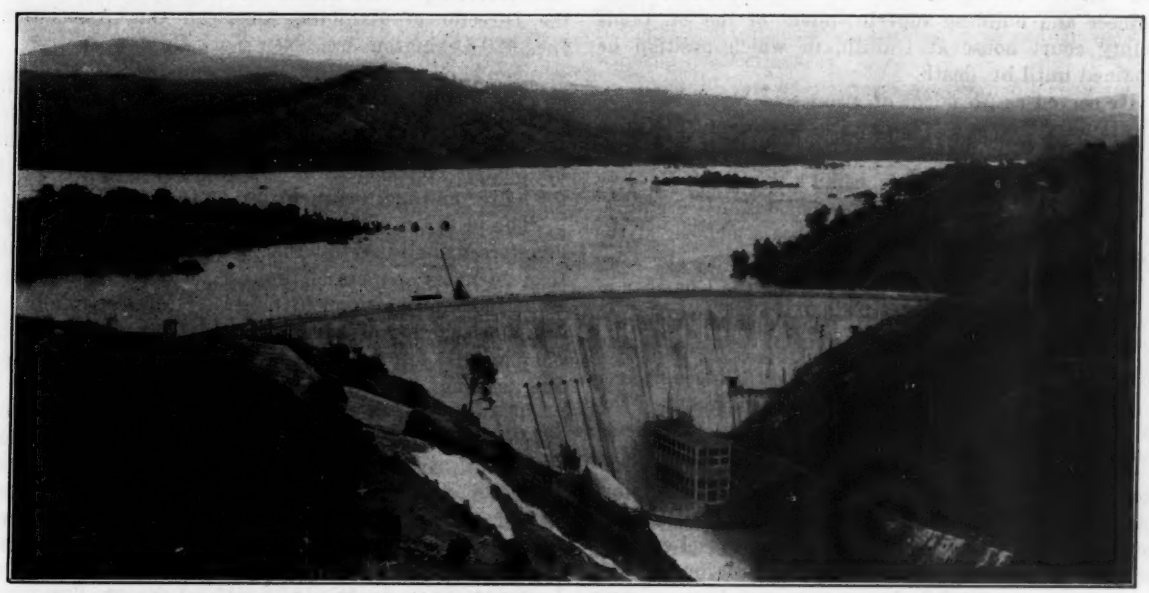
CAPACITY OF THE Don Pedro hydro-electric plant of the Turlock and Modesto irrigation districts, California, is being increased by the installation of two S. Morgan Smith, Francis type turbines of 10,350 hp. each and two Allis-Chalmers vertical generators of 9370 kv.a. each. This new equipment together with the three existing 7500-hp. S. Morgan Smith turbines will give the plant a total capacity of approximately 42,000 hp. With the exception of the actual requirements of the farms in the Irrigation District, all this power is purchased by The San Joaquin Light and Power Co. and the Pacific Gas & Electric Co.

New equipment for the Don Pedro plant also includes two Westinghouse 9370-kv.a. three-phase transformers and a Westinghouse 2500-kv.a. motor-generator set. Control of the motor generator set is by means of a liquid slip regulator, the first regulator of this type to be used on the Pacific Coast, although it is often used in the east. This will maintain the desired load under the condition of a difference of 3 cycles in the frequency of the two systems that purchase the power. There are also two Westinghouse 2500-kv.a. 3-phase transformers to be used with the motor generator set.

Alabama Power Co. to Build Lock 17 Plant

AUTHORIZING THE INSTALLATION of a hydro-electric power plant at the Lock 17 dam of the U. S. Government on the Warrior River, a certificate of convenience and necessity, was issued to Alabama Power Co. by the Alabama Public Service Commission on August 12. Application for a license under the terms of the Federal Water Power Act, made to the Federal Power Commission on April 16, 1927, is still pending.

The proposed power plant layout contemplates the installation of the two 10,000-kw. units in a power house located immediately downstream from the west abutment of the dam and connected to the headworks section of the dam by steel penstocks, and a substation adjoining the power house along the west bank of the river. The present layout proposes an outdoor type power house with service gantry crane for handling all power house equipment.



DAM AND POWER HOUSE OF THE DON PEDRO PROJECT, TURLOCK AND MODESTO IRRIGATION DISTRICTS, CALIF.

Running from the plant to Tuscaloosa, a 44,000-v. transmission line will feed the power generated at the plant into the company's existing system.

The Lock 17 dam, located 27 mi. above Tuscaloosa and 41 mi. from Birmingham, is the last link in the system of projects built by the government to afford navigation between the confluence of the Warrior with

the Tombigbee and Cordova, Alabama. The lake formed by this dam covers 7800 acres and is known as "Lake Bankhead" in memory of the late Alabama senator, John H. Bankhead.

Present structures at Lock 17 include a spillway section of dam 1170 ft. long, which raises the level of the river 63 ft. above the normal channel, and a lock of two lifts of 31½ ft. each, the inside dimensions of the lock chambers being 52 by 285 ft.

John Quincy Adams Dies Suddenly

WHILE RETURNING from the 45th Annual Convention of the National Association of Stationary Engineers at Los Angeles, John Quincy Adams, retiring president of the association, died suddenly on August 28, at San Francisco. He was suddenly stricken by acute indigestion while stopping there with his family and a party of engineers and died alone in his hotel room.

Mr. Adams was born in Cheboygan, Mich., on May 23, 1878. At the age of 16, he began his engineering experience as fireman on a passenger steamer on the Great Lakes. At the age of 21 he was made assistant engineer on the old Pioneer coal dock in Duluth, later receiving a marine license for ocean-going ships of all sizes and a chief engineer's license for the state of Minnesota. From that time on his career included such positions as that of chief engineer on the passenger steamer Iroquois, the ocean-going yacht Alvina and the like. In the spring of 1915 he was appointed chief engineer and building superintendent of the St. Louis County court house at Duluth, in which position he remained until his death.

He served as president of Minnesota No. 3, N. A. S. E. of Duluth for two years and as president of Minnesota State Association for two years. He was active in fraternal circles in that state, being a thirty-third degree Mason and an officer of various Masonic organizations. At the time of his death he was a member of the City Hall Building Commission of Duluth, The City Planning Commission, the Rotary Club, the Chamber of Commerce and was financial secretary of the Duluth Chapter of Marine Engineers Benefit Association and trustee of Minnesota No. 3 of the N. A. S. E.

News Notes

RESEARCH at Rensselaer Polytechnic Institute is carried on regularly in the engineering laboratories. More than 70 investigations were in progress during the past year, including cement, electric welding, Diesel engines, water softening, filter sands, electric distribution systems, measurement of 3-phase a.c. power, heat-resisting material for furnaces and corrosion-resisting alloys.

Twelve research fellowships are maintained for men pursuing graduate work leading to a master's degree. They are open to graduates of any school of engineering or university and give the student an income of $600 a year with no charge for tuition. Research may be in chemical, electrical, mechanical or civil engineering, in chemistry, electro-chemistry, electro-metallurgy, physics or biology, four laboratories being available for the work, each with experienced professors to direct the work. More complete details can be obtained by writing the Registrar of the Institute at Troy, N. Y.

FROM SEPTEMBER 12 to 16 the thirty-fourth Annual Convention of the Pacific Coast Gas Assn. was held at Santa Cruz, Calif. A well-arranged, unusually complete program was carried out, the first day being devoted to general sessions with simultaneous sessions of the accounting, commercial, public relations and technical sections being held on the succeeding four days.

Every phase of the subject was considered, the technical program dealing with papers on operation, design, experience and research. Considerable attention was given to load factors, peak loads, unaccounted for gas, main location, meter inspection and connections.

On Friday, September 16, a symposium on operation was held, discussing such problems as manufacturing costs, oil sprays for gas generators, automatic control of gas generators, soil corrosion of pipe, stream pollution, small plant operation and the need for accurate flow formulas.

Automotive transportation was made the subject of several papers dealing with all phases, from body design to accounting methods used by the different companies. In a well-arranged social program was included inspection trips and reception and, on the first evening, a first aid contest with five different companies competing, was held in the Casino.

AMERICAN GAS ASSOCIATION, INC., will hold its 9th annual convention and exhibition from October 10 to 14 at the Stevens Hotel, Chicago, Ill. All correspondence referring to the exhibition should be addressed to the Director of Exhibits, American Gas Association, Inc., 420 Lexington Ave., New York City.

THE FIRST NATIONAL FUELS MEETING, to be held in St. Louis, Mo., October 10-13, under the auspices of the Fuels Division of the A. S. M. E., will constitute the first major engagement of this group in the campaign for better and more efficient use of fuels.

The program will include papers of a general nature of interest to all users of fuel; papers on fuels in industrial furnaces; papers of interest to the central station man, and smoke-abatement papers of interest to all. A complete detailed program of the sessions was published on page 911 of the August 15 issue of Power Plant Engineering.

The morning of the first day of the meeting will be devoted to registration at headquarters in the Statler Hotel with an address at 11:00 a. m. on the general subject of fuel by Professor S. W. Parr of the University of Illinois. In the afternoon there will be a general session and the evening will be devoted to a smoker for the men and a reception for the ladies. After the technical session on Tuesday, a banquet and mass meeting of engineers and the Smoke Abatement League of St. Louis is scheduled.

In addition to the technical features of the meeting, inspection tours will be conducted throughout the period. No definite time has been set for particular tours, but parties will be formed from the registration list at convention headquarters. A committee is preparing a program for the ladies, to be announced later.

THE BROWN INSTRUMENT CO., Philadelphia, Pa., has established a new branch office in charge of F. M. Poole, district manager, at 509 Mutual Bldg., Kansas City, Mo.

APPOINTMENT OF PAUL HECHT of the South Philadelphia Works of the Westinghouse Electric & Manufacturing Co. as assistant to the vice president is announced by H. T. Herr, vice president of the company.

THE YELLOW TRUCK & COACH MFG. CO., a division of the General Motors Corporation, General Motors Bldg., Detroit, Mich., has plans for a new steam power house at its proposed plant at Pontiac, Michigan.

THE BOSTON & ALBANY RAILROAD CO., South Station, Boston, Mass., has approved plans for a new power plant at its local shops, estimated to cost $45,000.

WADE ENGINEERING CO. of Los Angeles, Cal., which handles products of The Lincoln Electric Co., has moved its northern office from 69 Webster St., Oakland, to 533—539 Market St., San Francisco.

OFFICIALS OF THE MOHAWK-HUDSON POWER CO. are organizing a new company to be known as the New York Power & Light Corporation to take over and operate a number of properties, including the Adirondack Power & Light Co., Troy Gas Co., and others.

THE GRAYS HARBOR RAILWAY & LIGHT CO., Aberdeen, Wash., has taken preliminary surveys for the construction of a new hydroelectric power plant on the Cowlitz River at a place known as Mossy Rock. Project is to cost about $7,000,000 and is scheduled for completion in about two years. W. W. Briggs is vice president and general manager.

THE EMPIRE DISTRICT ELECTRIC CO., Joplin, Mo., is making an addition to its Riverton Plant. This includes construction of a new building connected by a switching gallery with the existing turbine room which will later be extended to house additional turbine and boiler units. For the present the company is installing a 25,000-kv.a., 25-60 cycle frequency changer and is building a 30-mi., 132,000-v., 60-cycle transmission line to connect with the Neosho plant of the Kansas Gas & Electric Co. The present 100,000-kv.a. system is 25-cycle, all lighting load being supplied through frequency changers. Future additions, however, will be made 60-cycle and the system will be gradually changed to that frequency.

THE CITY WATER, LIGHT & POWER CO. at Fulton, Mo., has just completed the installation of two 350-hp. Heine boilers. Work is now being started on the installation of one 781-kv.a. Westinghouse turbo-generator. At present this plant is using one 187-hp. Hamilton Corliss engine and one 450-hp. Nordberg uniflow. A new 2000-gal. spray pond will also be installed. W. J. McCarroll, superintendent of the plant, is in charge of the construction. The new unit will be in operation by January 1.

THE UNITED STATES BUREAU OF RECLAMATION, Wilda Bldg., Denver, Colo., has tentative plans under way for a new hydro-electric power plant at American Falls, Idaho. Raymond F. Walter is chief engineer.

THE SOUTHERN CALIFORNIA EDISON CO., Los Angeles, has filed plans for the construction of a new steam generating station at Terminal Island, estimated to cost $850,000. Stone & Webster, Inc., is engineer and contractor.

THE UNITED POWER & LIGHT CORP. of Kansas has recently completed an extension to the Hutchinson plant including the installation of a 12,500-kw. turbo generator with auxiliaries. McClellan & Junkersfeld, Inc., was consulting engineer.

THE NORTHWEST PULP & PAPER CO., Astoria, Ore., plans to build a power plant using high pressure boiler units and steam-driven generators in its proposed pulp and paper plant. The entire project is estimated to cost $650,000. Henry M. Ford is consulting engineer.

THE KNOXVILLE POWER CO., Knoxville, Tenn., operated by the Aluminum Co. of America, plans construction of an 80,000-hp. hydro plant on the Tennessee River. James W. Rickey is company engineer.

Books and Catalogs

REPAIR SHOP DIAGRAMS and Connecting Tables for Induction Motors, by Daniel H. Braymer and A. C. Roe. First edition 227 pages, size 6 by 9, cloth, $2.50. New York, N. Y., 1927.

The object of this book is to furnish repair men and armature winders with practical step by step instructions on the laying out of coils for induction motor windings and connecting the ends of the groups of these coils in proper sequence of phase and pole group for different types of windings used in motors from 2 to 24 poles, 2 and 3 phase. It should be of value not only to repair men in repair shops but to maintenance men in industrial plants who have occasion to change existing winding connections.

Although sets of diagrams are available showing the theoretical layout of coils in an induction motor, the winder is required to spend considerable time in studying out the actual connections before he can proceed with the connecting and in many cases he finds it necessary to draw up a new diagram to represent the particular winding he is working on. In this book, all this has been done for him. Each diagram is a practical shop drawing marked with proper connections for the ends of all phase groups of coils so that they can be actually followed by the winder. Tables are provided giving the number of coils in the different phase groups and the markings for the ends of these groups as indicated in the diagrams. Throughout the book the shopman is kept in mind and to him the book should prove of great value.

MCCLELLAN & JUNKERSFELD, INC., 68 Trinity Pl., New York, has just issued a 42-page bulletin containing a report on proposed auxiliary steam station and central steam heating plans for Toronto Hydro-electric System, Toronto, Canada. The report recommends that serious consideration be given to the construction and operation of the auxiliary steam electric station, either alone or in combination with a central heating plant.

Part II of the report presents data on which this conclusion is based. Anaylsis of load conditions; cost of hydro power; cost of steam plant operation; consideration of plant site; relation of steam heating system and estimates of cost are given. Finally, general arrangement, plans and approximate costs for various combinations are presented and the entire report forms a good example of the care and attention to detail

necessary in analyzing a situation of this kind. A. G. Christie acted as advisory engineer with McClellan & Junkersfeld, Inc.

THE SUB-COMMITTEE on Auxiliary Testing Apparatus, Meter Committee, National Electric Light Assn., 29 W. 39th St., New York City, has made a careful survey of all recent developments, either by manufacturers or by utilities, in auxiliary testing apparatus. A report recently issued by this committee incorporates the results of the survey, presenting in condensed form all essential data on each development.

GENERAL ELECTRIC Co., Schnectady, N. Y., in Bulletin GEA-765 describes the CR7006-D20 magnetic switch, an across-the-line starter for single-phase and three-phase induction motors. Bulletin GEA-754 describes semi-automatic reduced voltage starters for synchronous motors.

IN THE AUGUST 15 ISSUE of The Delta Star, published by Delta-Star Electric Co., 2400 Block, Fulton St., Chicago, Ill., are published many interesting photographs of various high voltage electrical testing laboratories throughout the country.

IN A REPORT on Fishways issued in July, 1927, by the Hydraulic Power Committee of the National Electric Light Assn., 29 W. 39th St., New York City, a discussion is given of various means that have been devised for passing fish over dams or other obstructions in rivers of the Northwest. The ordinary pool type of fish ladder appears to be satisfactory for small lifts, but for high dams, it seems that some form of hoist or other mechanical device will be required. Several of these mechanical schemes are described and experience with their operation is given in the report.

ACCORDING TO a recent statement by the Department of Commerce, considerable investigation has recently been made by the Bureau of Mines concerning various processes for producing aluminum or aluminum compounds, in view of the fact that most of the bauxite from which aluminum compounds are derived must be imported from abroad. For political as well as economic reasons it is thought well to consider the utilization of other aluminous minerals within our own borders. Details of this investigation, conducted by the Pacific Experiment Station of the Bureau of Mines, Berkeley, Calif., are reported in bulletin 267. Copies of this may be obtained for fifteen cents from Supt. of Documents, Government Printing Office, Washington, D. C.

SAVINGS by changing from ordinary steam to that free of all soluble and insoluble solids to not over nine parts in a million as shown by condensate, also with not over 0.2 of one per cent of moisture are conveniently arranged for tabulation in the Calculation Book published by Andrews-Bradshaw Co. of Pittsburgh, Pa. Headings listed are steam savings due to clean turbine blades, saving of costs of shutdowns to clean and cleaning of blades, erosion of blades and reblading; savings in steam economy, cylinder oil, repairs and shutdowns in engine plant; saving due to better superheat and reduced maintenance on superheaters; savings due to clean steam piping and process equipment; additional savings due to freedom from water and dirt which cause wear on cylinders, valves, safety devices packing and superheater. Tabulation is also arranged for weight of impurities entering the boiler and that carried into the steam system.

THE WEBSTER MFG. Co., Chicago, Ill., in catalog No. 50, describes and illustrates Webster quality chains and sprockets. A price list as of July 1, 1927, is included in this bulletin.

BETHLEHEM STEEL Co., Bethlehem, Pa., in a recent 24-page illustrated bulletin, describes Bethlehem Diesel engines, Type S, two-cycle airless injection type for stationary service.

WORTHINGTON PUMP & MACHINERY CORP., 115 Broadway, New York City, in bulletin No. S-173, recently issued, describes and illustrates the Worthington double-acting two-cycle Diesel engine.

THE NEW DEPARTURE MFG. Co., Bristol, Conn., in a recent twenty-page booklet, discusses "Cutting Your Costs, or What New Departure Ball Bearings Mean in Your Motor."

J. P. FLIPPEN, Union Trust Bldg., Pittsburgh, Pa., has just issued a 4-page illustrated folder describing the Monitor condenser tube sheet cleaner, designed to clean tube sheets of condensers while they are in operation.

SULLIVAN MACHINERY Co., 122 S. Michigan Ave., Chicago, Ill., has recently issued three new bulletins. Portable air compressors, gasoline engine driven and electric motor driven, are described in bulletin 83-F. Bulletin 76-F, third edition, describes the Sullivan air turbine-driven portable hoists. Bulletin 81-N describes the new model Sullivan Clay Spaders for excavating clay underground, or in open trenches.

THE NEW water supply system at Tampa, Fla., was recently described and illustrated in an elaborate paper presented by Nicholas S. Hill, Jr., consulting engineer, before the New England Water Works Association. Thorough studies were made of sources of water supply, and available supplies were treated experimentally to determine the most suitable treatment process, including decolorizing, softening and recarbonization, as well as sedimentation and filtration. The paper has been reprinted and is being distributed by the De Laval Steam Turbine Co., Trenton, N. J., manufacturers of the geared turbine driven centrifugal pumps installed in the low head pumping stations of the system.

AN AUTOMATIC pumping station installed by the City of Independence, Mo., is described in a leaflet published by the De Laval Steam Turbine Co., Trenton, N. J. Three pumps are driven by electric motors and the automatic equipment controls the water level in the storage reservoir by making various combinations of the pumping units. When one pump is unable to maintain the pressure, the next larger pump is started and the smaller pump drops out, and if the level continues to drop, the second pump gives way to the third or largest unit. For still greater demand, the first and third units are operated, then the second and third, and finally for maximum demand, all three pumps come into service. The installation has operated satisfactorily.